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ORIGINAL ARTICLES.

I.—On Some Fossil Ostracoda from S.-W. Wyoming, and from Utah, U.S.A.

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§ 1. *Introduction.*

In 1885 Dr. C. A. White, F.C.G.S., Palæontologist to the U.S. Geological Survey, supplied me with some of the siliceous residue of a limestone belonging to the freshwater Jurassic *Atlantosaurus*-beds in Colorado, from which several casts of small Ostracoda were figured and described in the Geological Magazine,[1] Dec. III. Vol. III. April, 1886, pp. 145–8, Pl. IV. Since that time Dr. White has kindly sent me somewhat similar material, obtained in like manner, by dissolving in dilute acid pieces of an impure limestone, which lies at the base of the Upper Cretaceous Series, from Cokeville, a hamlet in South-Western Wyoming, and belongs to the Bear-River Formation. The Ostracoda selected are figured in Plate XV. Figs. 1–9, 11–13, and 15. These casts represent the whole carapace in many if not all instances.

All the known fossils from the deposit yielding these specimens, Dr. White tells me, are either fresh-water or brackish-water forms (none marine). Of these under notice, however, Figs. 11 and 12 belong to a marine genus. The *Chara*, occurring abundantly with these fossils from S.-W. Wyoming, has been published by

[1] Also noticed in the "Bulletin U.S. Geol. Survey," No. 29, May, 1889.

Mr. F. H. Knowlton (in the "Botanical Gazette," vol. xviii. p. 141 figs. 1–3), as *Chara Stantoni*. It has much of the appearance o some of the *Charæ* found in the Oligocene beds of the Isle of Wight Various species of *Pyrgulifera*, *Corbula*, *Unio*, *Limnæa*, and *Neritina* are found as siliceous casts with the Chara.

Dr. White has also sent to me a piece of shale containing Ostracoda with their tests preserved, but very fragile; this specimen was from the Montana Formation, near the top of the Upper Cretaceous Series, at Coalville, Utah, about 40 miles from Salt-Lake City. Some examples are illustrated by Figs. 10, 14, and 16, belonging to brackish- or, more probably, fresh-water genera.

Upper Cretaceous Series.	Laramie Formation.	
		⋖ Place of the shale from Utah.
	Montana Formation.	
	Colorado Formation.	
	Bear-River Formation.	Place of the specimens obtained by dissolving the impure limestone from S.-W. Wyoming.
	Dakota Formation.	

Some of the specimens from S.-W. Wyoming, now figured, remind us of those from Colorado, above-mentioned; others are different; but nearly all appear to represent either freshwater or estuarine forms; and are thus in accord with the other known fossils of the Upper Cretaceous beds from which they have come.

The selected specimens are described in their natural order according to the classification of the Ostracoda.

§ 2. *Description of the Species.*

I. Cypris, Müller, 1785.

1. Cypris Purbeckensis, E. Forbes. Pl. XV. Figs. 15*a*, 15*b*.

Quart. Journ. Geol. Soc. vol. xli. 1885, pp. 347–8, pl. 9, figs. 1–6.
Length ·5, height ·3, thickness ·15 mm.

Fig. 15*a* is referable to *Cypris Purbeckensis*, being like figs. 3–5 of those figured and described in 1885 (*op. cit.*); it is, therefore, evidently equivalent to figs. 5*a*, *b*, *c*, Pl. IV. Geol. Mag. 1886, p. 147, illustrating the same form from Colorado.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

II. Cypridea, Bosquet, 1852.

Quart. Journ. Geol. Soc. vol. xli. 1885, p. 336.

2. Cypridea tuberculata (Sowerby, *op. cit.* p. 342), var. Wyomingensis, nov. Pl. XV. Figs. 5*a*, *b*; 6*a*, *b*.

Fig. 5. Length ·95, height ·6, thickness ·35 mm.
Fig. 6. —— 1·05, —— ·6, —— ·4 mm.

This comes very near to *Cypridea tuberculata* (Sow.), var. *adjuncta*, Jones (*op. cit.* p. 342, Pl. VIII. Figs. 22–24), but its antero-dorsal angle (anterior hinge) is stronger, giving a more pronounced slope to the dorsal border; its notch and hood are stronger; its tubercles are not so strong; the valves are not so convex, hence the edge-

view is narrower. Some few individuals (figs. 6*a*, *b*, for instance) have a strong dorsal depression just behind the front hinge, and a deformation of the antero-ventral border. This furrow is irregular; but the largest example is figured here. Sometimes the depression consists of two narrow sub-triangular hollows. It is difficult to determine if this be a varietal character, or the result of accident or disease.

The original *Cypridea tuberculata* (Sowerby) is sub-quadrate and relatively shorter and thicker than either var. *adjuncta* or the form under notice. The latter is sufficiently distinct to have a varietal name—*Wyomingensis*

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

III. Potamocypris, Brady, 1870.

3. Potamocypris affinis, sp. nov. Pl. XV. Figs. 8*a*, *b*.

Length ·7, height ·4, thickness ·22 mm.

This is not far distant in shape from *Cytherideis* [?] *Marshii*,[1] Jones; but it is more oblong, being less attenuate posteriorly, and has not so great a lateral convexity.

Some of the fossil Ostracoda formerly referred to *Cytherideis* probably belong to *Potamocypris*; and I think that *C. Marshii* and the specimens now under notice should be regarded as belonging to this genus. I propose to name the present form as *P. affinis*. The species of this genus live in fresh and brackish waters.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

4. Potamocypris unisulcata, Jones. Pl. XV. Figs. 10*a*, *b*.

Length 1·05, height ·65, thickness ·45 mm.

The "*Cytherideis*" *unisulcata*, Jones, Monogr. Tert. Entom., Pal. Soc. 1856, p. 48, pl. iv. fig. 10, and Suppl. Monogr. 1889, p. 46, was regarded as a doubtful species; but (its proposed genus, *Cytherideis*, having been revised and limited by G. S. Brady and A. M. Norman, 1889) its right place is in *Potamocypris*. To this *P. unisulcata* the present species aptly coincides. Its transverse furrow is at first sight a differential characteristic; but we find so many genera having species impressed with a more or less distinct transverse furrow[2] that we cannot remove this form from *Pontocypris* on account of that feature.

P. unisulcata occurs in the green shale of the Osborn Series, Cliff End,[3] Isle of Wight, with *Candona Forbesii*, Jones, also *Paludina*, *Melanopsis*, *Melania*, *Lepidosteus* and remains of Alligator.

Fig. 10 is from the Montana Formation; Coalville, Utah.

[1] Geol. Mag. 1886, p. 147, Pl. IV. Figs. 6*a*, *b*, *c*.

[2] A more or less perfect furrow marks the valves in some species of *Cypris*, *Limnicythere*, *Cytheridea*, *Cythere*, *Cytheropteron*, *Bythocythere*, *Cytherella*, *Cypridina*. In the foregoing the sulcus is often rare and always irregular; but it holds good, however, more definitely as a generic character in the Palæozoic *Entomis* and *Entomidella*, although partially shown in some contemporary genera, especially *Primitia*.

[3] Mem. Geol. Surv., Isle of Wight, 2nd edit., by Reid and Strahan, 1889, p. 150.

IV. Candona, Baird, 1845.

5. Candona subreniformis, sp. nov. Pl. XV. Fig. 14 *a*, *b*.

Length, 1·2, height ·6, thickness ·5 mm.

This approaches the female form of *Candona Kingsleii*, Brady and Robertson (see Trans. R. Dublin Soc. ser. 2, vol. iv. 1889, p. 102, pl. ix. figs. 19, 20), in shape; but it is relatively fuller in the posterior third.

From the Montana Formation; Coalville, Utah.

6. Candona subovata, sp. nov. Pl. XV. Figs. 16*a*, *b*.

Length 1·2, height ·65, thickness ·65 mm.

Although subovate, almost subreniform, and with a low front, its lateral aspect is too long and narrow in proportion, and its edge view too thick for *Cypris incongruens, Ramdohr*,[1] nor has it the slight, flattened margin of that form.

So also it is not unlike *Cypris*? *Cambrica* (female), Brady and Robertson (Ann. Mag. N.H. ser. 4, vol. ix. 1872, p. 55, pl. ii, figs. 3, 4), except that it is fuller at the middle and posterior thirds, and more convex at the sides, so that in the broadly-lanceolate edge view the anterior extremity is not so sharp, and the posterior is quite blunt.

Among the figures of *Candona candida*, male and female, and its varieties, shown in the Trans. R. Dublin Soc. 1889. pl. x. figs. 14–23, figs. 18 and 19 (female) are somewhat like our fig. 16, but rather less plump, not so convex on the back, and too sharp at the ends in the edge view. Figs. 20 and 21, except that they project too much at the postero-ventral region, have a closer resemblance to fig. 16 than the foregoing; and I think it most probable that both fig. 14 and fig. 16 are referable to the same genus (*Candona*), but they differ specifically from any that I know.

From the Montana Formation; Coalville, Utah.

7. Metacypris subcordata, sp. nov. Pl. XV. Figs. 2*a*, *b*, *c*.

Length ·6, height ·35, thickness ·5 mm.

This *Metacypris* approaches the well-known recent *M. cordata*, Brady and Robertson,[2] especially the female form; but the transverse constriction more strongly impresses the lateral convexity, the dorsal region in each valve is more depressed and sloping, and the ventral region is more deeply excavated. The surface is marked with a shallow, irregular pitting, almost a reticulation.

The specific name, *M. subcordata*, is applicable, in allusion to its recent ally.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

8. Metacypris consobrina, sp. nov. Pl. XV. Figs. 1*a*, *b*, *c*.

Length ·45, height ·25, thickness ·4 mm.

This is evidently a *Metacypris*, and nearly allied to both *M. Forbesii*,

[1] Magaz. Ges. nat. Freunde zu Berlin, II. Quartal, 1808, p. 86, pl. iii. figs. 19, 20; also Brady, Trans. Linn. Soc. 1868, p. 362, pl. xxiii. figs. 16–22.

[2] See Trans. R. Dubl. Soc. n.s. vol. iv. 1889, p. 123, pl. xiv. figs. 3-12, for latest notice, by Brady and Norman.

Jones, and *M. Bradyi*, Jones (Geol. Mag. 1886, Pl. IV. Fig. 1 and Fig. 2); it is, however, smaller, relatively shorter, plumper, and less strongly constricted across the middle than *M. Bradyi*; and smaller, longer (relatively), and more oblong than *M. Forbesii*; its transverse sulcus, also, is quite medial, and not at the anterior third as in the latter. Being thus quite distinct, although related, it may have the new specific name of *M. consobrina*. The surface has a shallow, irregular pitting.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

9. Metacypris cuneiformis, sp. nov. Pl. XV. Figs. 3*a*, *b*, *c*.

Length ·65, height ·35, thickness ·3 mm.

Oblong; compressed anteriorly, convex behind; almost straight on the parallel dorsal and ventral borders, the former compressed and sharp, the latter deeply sunken, giving a sagittate outline to the end view (Fig. 3*c*.) of the carapace, whilst the dorsal view (Fig. 3*b*.) is lanceolata. The ends are rather obliquely, and unequally rounded.

Having much of the appearance of an oblong wedge, this species may be conveniently termed *M. cuneiformis*. The surface does not show any marking.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

10. Metacypris simplex, sp. nov. Pl. XV. Figs. 9 *a*, *b*, *c*.

Length ·4, height ·2, thickness ·2 mm.

Suboblong, but broader (higher) at the anterior third than behind, both ends truncate; the front slightly oblique, and the hinder end gently rounded. The valves are convex; edge view, acute oval; end view, broadly cordate (reversed).

This is smaller, less truly oblong, and more uniformly convex than *M. cuneiformis*, and has to be regarded as a distinct species. The surface is faintly reticulate.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

The known species of *Metacypris* are:—

M. glutea (Egger.). Neues Jahrb. etc. 1858, p. 408, pl. i. fig. 6.
M. strangulata,[1] Jones, Q. J. G. S. vol. xvi. 1866, p. 187, fig. 73.
M. cordata, Brady and Robertson, Ann. Mag. Nat. Hist. ser. 4, vol. vi. 1870, p. 20, pl. vi. figs. 1—9; and Trans. R. Dublin Soc. n.s. vol. iv. 1889, p. 123, pl. xiv. figs. 3—12.
M. Forbesii, Jones, and var. *verrucosa*, Jones, Q. J. G. S. vol. xli. 1885, p. 345, pl. viii. figs. 11—13.
M. Bradyi, Jones, Geol. Mag. 1886, p, 146, Pl. IV. Fig. 2.
M. Whitei, Jones, *loc. cit.* Fig. 3.
M. Fittoni (Mantell), Jones in Prestwich's "Geology," vol. ii. 1888, p. 263, fig. 137*a*; and Geol. Mag. 1888, p. 539.

VI. Cythere, Müller, 1785.

11. Cythere monticula, sp. nov. Pl. XV. Figs. 13*a*, *b*.

Length ·6, height ·35, thickness ·6 mm.

Looking for published species showing definite alliance in form to this specimen, *Limnicythere*, a brackish genus presents itself; but there is no real ground for regarding relationship to exist. *Cythere*

[1] *Cypris conculeata*, Jones, Q. J. G. S., vol. xvi. 1866, p. 266, fig. 3, is not a *Metacypris* for certain.

Cluthæ, Brady, Crosskey, and Robertson,[1] which presents variable aspects, with its irregular mammillated surface and subquadrate carapace, is decidedly a nearer ally.

In our specimen the valves are broad (high) in front, narrow and subtruncate behind, the dorsal and ventral borders sloping backwards and the ventral region bears a definitely sharp ridge (not broad and rounded as in *C. Cluthæ*) for two-thirds of its length. There is also a central tubercle on the valve, with a swelling in front and behind it.

Differing in marked features from the other species, this may be designated *Cythere monticula*.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

VII. Cytheridea, Bosquet.

12. Cytheridea truncata, sp. nov. Pl. XV. Figs. 4*a*, *b*.

Length ·7, height ·5, thickness ·3 mm.

There is no evidence of the Cypridean hook in this form, though it has some resemblance to a possibly truncate form of *Cypridea punctata*[2] (Forbes); but I prefer to associate it with *Cytheridea*. Its subtrigonal shape, with truncate front, and oblique posterior end, are characteristics. Its edge view is narrow-oval.

On the surface is visible a shallow pitting, looking almost like a reticulation.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

13. Cytheridea tenuis, sp. nov. Pl. XV. Figs. 7*a*, *b*.

Length ·6, height ·25, thickness ·2 mm.

This is another form probably belonging to *Cytheridea*. The cast (like Fig. 4) has not retained (if it ever had) any evidence of the Cypridean beak-like process and its accompanying notch. It has a long subtriangularly ovate shape, like that of many different kinds of Ostracodes. The front is well rounded; the posterior rounded, but narrow; the ventral border is straight; the dorsal elliptical, and most convex at the anterior hinge, as in many of the *Cytheridæ*. The surface shows some slight tuberculation.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

VIII. Cytherideis, Jones, 1857; and Brady and Norman, 1889.

14. Cytherideis æqualis, sp. nov. Pl. XV. Figs. 11*a*, *b*.

Length ·6, height ·25, thickness ·4 mm.

It is difficult (if not impossible) to place this form among fresh-water and brackish Ostracoda. The *Cypridopsis villosa* (Jurine), as defined by Brady, has a narrow and curved carapace, but more arched on the back and thicker in the middle than Fig. 11. The genus *Cytherideis*, of which only marine forms are known, offers a more convenient asylum for this narrow, curved carapace with the ends equally rounded, but with an anterior compression of the valves

[1] Monogr. Post-Tert. Entom., Pal. Soc., and more lately treated of by Brady and Norman in Trans. R. Dublin Soc., n.s., vol. iv. 1889, p. 145, pl. xiv. figs. 25–27; and pl. xviii. figs. 25 and 26.

[2] Quart Journ. Geol. Soc. vol. xli. 1885, p. 357, pl. viii. figs. 1–8.

(Fig. 11*a*.), giving a sharp-lanceolate edge view (Fig. 11*b*.). In this case *Cytherideis gracilis* (Reuss) and *C. botellina* (Jones) are among its nearest allies; but neither of them matches it exactly. I propose to name it *C. æqualis*.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

15. Cytherideis impressa, sp. nov. Pl. XV. Figs. 12*a*, *b*.

Length ·6, height ·25, thickness ·17 mm.

A narrow and curved carapace of nearly equal thickness throughout except where constricted with a broad and shallow impression in the middle of the ventral region.

From the Bear-River Formation; Cokeville, S.-W. Wyoming.

EXPLANATION OF PLATE XV.

All the figures magnified 20 diameters.

Fig. 1. *Metacypris consobrina*, sp. nov.; *a*, carapace, left valve shown; *b*, edge view; *c*, end view.
,, 2. ——— *subcordata*, sp. nov.; *a*, left valve shown; *b*, edge view; *c*, end view.
,, 3. ——— *cuneiformis*, sp. nov.; *a*, right valve shown; *b*, edge view; *c*, end view.
,, 4. *Cytheridea truncata*, sp. nov.; *a*, left valve shown; *b*, ventral edge.
,, 5. *Cypridea tuberculata* (Sow.), var. *Wyomingensis*, nov.; *a*, right valve shown; *b*, ventral edge.
,, 6. The same; *a*, left valve shown; *b*, ventral edge.
,, 7. *Cytheridea tenuis*, sp. nov.; *a*, left valve shown; *b*, edge view.
,, 8. *Potamocypris affinis*, sp. nov.; *a*, right valve shown; *b*, ventral edge.
,, 9. *Metacypris simplex*, sp. nov.; *a*, right valve shown; *b*, edge view; *c*, end view.
,, 10. *Potamocypris unisulcata*, Jones; *a*, left valve; *b*, edge view.
,, 11. *Cytherideis æqualis*, sp. nov.; *a*, carapace, left valve shown; *b*, edge view.
,, 12. ——— *impressa*, sp. nov.; *a*, right valve shown; *b* edge view.
,, 13. *Cythere monticula*, sp. nov.; *a*, left valve shown; *b*, ventral view.
,, 14. *Candona subreniformis*, sp. nov.; *a*, right valve; *b*, edge view.
,, 15. *Cypris Purbeckensis*, E. Forbes; *a*, carapace, right valve shown; *b*, edge view.
,, 16. *Candona subovata*, sp. nov.; *a*, right valve shown; *b*, edge view.

II.—The Evolution of the American Tapir.

By Charles Earle, B.Sc.,
of the American Museum of Natural History, New York.

THE genus *Tapirus* of all the recent Ungulata, is the most discontinuous in its distribution over the Earth's surface. Wallace, in his great work on the "Geographical distribution of Animals," in referring to extinct Tapirs, remarks: "the singular distribution of the living species is thus explained, since we see that they are an old world group, which only entered the American continent at a comparatively recent epoch." He reaches this conclusion by the fact that at the time his work was written (1876) the only known remains of the Tapiridæ in America were from the Post-Pliocene deposits.

Our knowledge has been greatly increased as regards fossil tapirs in America within the past few years, and the discovery of the genus *Protapirus* of Filhol, by the expedition sent out by the American Museum of Natural History in the Lower Miocene of Western Dakota, has added another very important link in the phylogeny of

the American Tapir. This discovery places the origin of the Tapir in America on a level stratigraphically with one of the species of *Protapirus* in Europe. We shall therefore expect that further discovery will perhaps prove the existence of the true Tapir in America, earlier than the Oreodon beds of the White River Miocene.

Many authors have attempted to solve the problem of the origin of the Tapir in America. Professor Marsh[1] in 1877 held the view that the genus called by him *Helaletes*, was the ancestor of the true Tapir. Professor Scott[2] followed Marsh in deriving the Tapir from *Helaletes* (*Desmatotherium*).

Prof. Cope[3] was the first investigator to recognize that in the Wasatch and overlying Wind River beds, two types of Tapiroid superior molars were already then evolved. In the one, *Systemodon*, both external lobes are conical, and in the other *Heptodon*, the postero-external lobe is concave. This point is of great importance as shown by Prof. Osborn in tracing the ancestral history of these Perissodactyla. Prof. Osborn[4] in the "Uinta Mammalia" removed *Helaletes* from the line leading to the true Tapirs, and placed *Systemodon* as *the stem* form of the latter. Later, Prof. Osborn[5] explained more fully his reasons for removing *Helaletes* from the Tapir line, and in this paper characterized the form of the superior molars in the three Tapiroid phyla of the Eocene.

The recent discovery of *Protapirus* in America shows that this genus was represented by two species, one derived from a division of the White River Miocene (Oreodon beds), lower than the other (Protoceras beds). If we carefully compare the species of *Protapirus* figured by M. Filhol[6] with those found in America[7] we will find a remarkably close resemblance in the characters of their teeth, and in fact it is quite difficult to separate the *Protapirus obliquidens* from the *P. Douvillei* of St. Gérand-le-Puy.

In studying the early ancestors of the Tapirs in the Eocene of America, we observe certain differences in their foot-structure, and in the simplicity of the premolar teeth. These characters differentiate the early Tapirs from the later or true Tapirs. We notice first, that the earliest known Tapiroid, namely *Systemodon*, has the premolars less complex in structure than the true molars, and only the third and fourth superior premolars in this genus have internal cones. The upper true molars consist of two conical external lobes, which are of equal length transversely. This is a very important character in diagnosing the early Tapiridæ from the Rhinocerotidæ.

[1] O. C. Marsh, Introduction and succession of Vertebrate Life in America, delivered before the American Association at Nashville, 1877.

[2] W. B. Scott, On *Desmatotherium* and *Dilophodon*, two new Eocene Lophiodonts, Bull. Princeton College, 1883, p. 46.

[3] E. D. Cope, The *Perissodactyla*, American Naturalist, 1888, p. 990.

[4] W. B. Scott and H. F. Osborn, The Mammalia of the Uinta Formation, Trans. Amer. Phil. Soc. 1889, p. 523.

[5] H. F. Osborn and J. L. Wortman, Fossil Mammals of the Wasatch and Wind River Beds, Bull. Amer. Mus. Nat. Hist. 1892, p. 124.

[6] H. Filhol, Reserches sur les Phosphorites du Quercy, 1877, p. 351.

[7] *Ibid.*, Observations sur le memoire de M. Cope, etc., Ann. Sci. Geol. vol. xvii. art. 2.

In the latter group, the postero-external cone of the upper molars in later forms has a tendency to lengthen and become concave. The upper molars of *Systemodon* are provided with two complete transverse crests and there is a large antero-external cingular cusp. The lower series of teeth in *Systemodon* exhibit an interval or diastema behind the first premolar. This tooth is placed, however, close to the canine, which is considered to be a character typical of the early Tapirs. The fourth inferior premolar in *Systemodon* is simpler in structure than a true molar; it has, however, two anterior cusps and a low heel. The latter is unprovided with a postero-internal cusp.

In the further evolution of the Tapir this is the tooth which becomes molariform in structure. The last lower molar of *Systemodon*, like all the Eocene Tapirs, has a large third lobe. This character, and the less complexity of the premolars, sharply divides the Lower Eocene Tapirs in America from their Miocene descendants. Wortman and Earle[1] have lately shown it is probable that *Systemodon* had a rudiment of the fifth metatarsal on the hind foot. In the contemporary genus *Hyracotherium* of the Wasatch, this metapodial had disappeared. As far as vertebrate palæontology has progressed in regard to the fauna of the Wasatch Eocene, we may conclude that the genus *Systemodon* may be considered as standing in ancestral relations to both the Tapiridæ and Rhinocerotidæ.

In the Wind River beds of America we meet with the genus *Heptodon*. This form has a superior molar indicating that it is off the line leading to the true Tapirs; the postero-external cusp has become concave, and reminds one of that occurring in the genus *Hyrachyus*. *Heptodon* is considered by Prof. Osborn to be the ancestor of *Helaletes* of the Middle Eocene. The *Heptodon-Helaletes-Colodon* line was a phylum of the Perissodactyla, contemporary with the *Systemodon-Isectolophus-Protapirus* line, but leading to a form (*Colodon*) more specialized than *Protapirus*. *Colodon* has lost the outer incisor of the lower jaw, and the fifth digit of the manus is much smaller than in *Protapirus*.

There has as yet been no representative of the true Tapir line discovered in the Wind River beds of America. In the Bridger we find the genus *Isectolophus*, which should probably be placed in the line leading to the Tapir. The dentition of this genus is not yet fully known, especially the species from the Uinta. In *Isectolophus latidens* the third superior premolar has two internal cones, but the fourth tooth of this series is still simple in structure, like that of *Systemodon*. The true molars closely resemble those of the latter genus. The structure of the last inferior premolar of *I. latidens* is not known, but it was probably nearly molariform. The lower true molars show little advance over those of *Systemodon*; the last lower molar still retains the large third lobe.

Referring to the Uinta Tapir, namely, *Isectolophus annectens*, we notice in this species that the external face of the upper molars is

[1] J. L. Wortman and Charles Earle, Ancestors of the Tapir from the Lower Miocene of Dakota, Bull. Amer. Mus. Nat. Hist. July, 1893.

more oblique than in the Wasatch Tapir, the last lower premolar is nearly transformed into the complexity of a molar. The last inferior true molar in this species is like that of the *I. latidens* in having a large third lobe. Until the structure of the upper premolars is known in the *I. annectens*, we cannot say with certainty whether this form led to the true Tapir.

The structure of the manus in *Isectolophus annectens* is of great interest, and illustrates the small change which the foot of the Tapir has undergone since the Upper Eocene. This species has four well developed toes on the anterior foot, and the fifth toe is larger in comparison with the size of the third than in the recent Tapir. The upper and middle element of the carpus, the lunar bone, has two nearly equal distal articular faces; this character of the lunar showing that the four digits of the manus are more nearly equal in size than in modern types.

In the evolution of the foot structure of the odd-toed Ungulates or Perissodactyles with the reduction of the toes, there has been a concomitant displacement of the carpal and tarsal elements. For example, one of the most primitive of the Ungulates, the genus *Phenacodus*, has these elements arranged one above the other, the serial order as it is called, and co-ordinated with this structure is the presence of five well-developed digits on each foot. In all the known species of the Tapir, however, there has taken place a high degree of displacement. We have observed[1] considerable difference in the foot structure of two species of recent Tapir, but all the modern forms are more specialized in this respect than their Eocene ancestors. The most noticeable change in the relations of the bones of the carpus in the evolution of the Tapir series, is the change in extent of articulation between the lunar and magnum, and the lunar and unciform. In the more specialized forms the anterior articulation between the lunar and magnum is shut off entirely; these relations are connected with the reduced size of the fifth toe, and as a result the lunar comes to have a large articulation with the external and inferior bone of the carpus, the unciform. These morphological characters are extremely important in tracing out the phylogeny of the Perissodactyla.

There is a break in the ancestral history of the Tapir in America between the Upper Eocene and the middle layer of the White River Miocene; in Europe this record is more complete than in America. The earliest known species of *Protapirus* from America is the *P. simplex* from the middle layer, or Oreodon beds of the White River formation. The only known remains of this species are the superior premolars and fragments of the lower jaw. It is of surprising interest to find a Perissodactyle so high up as the White River beds, having premolars so simple in structure. In all the other Perissodactyla of this epoch the premolars have become as complex as the true molars. In *P. simplex* the internal lobes of the superior premolars are absolutely simple in structure, and

[1] Charles Earle, Some points in the Comparative Osteology of the Tapir, Science, March, 1893.

consist of only a single internal cone. This species is nearly as large as its successor in the upper layer of the Lower Miocene.

The best known American species of *Protapirus* is the *P. obliquidens* from the Protoceras beds of the Lower Miocene. This species is represented in the American Museum Collection by the upper and lower dentition, and a finely-preserved manus. The comparison of the upper premolars of *P. simplex* with those of *P. obliquidens* reveals the fact that the internal cones of these teeth in the latter species are in a transition stage of development, and are intermediate in structure between those of the earliest species of *Protapirus*, viz. *P. simplex* and the recent Tapir. In the genus Tapirus the last three superior premolars are truly molariform, and consist of two external cones and two complete transverse crests; the latter being entirely separated internally. Now in *P. obliquidens* the internal cones of these teeth are deeply bilobed at their summits, especially the last two of the series; the anterior crest is well marked, but the posterior less so. It is interesting, from a phylogenetic point of view, to notice that the anterior crest of the premolars in the Tapiridæ is the first to be developed, and later the posterior appears by an elongation transversely of the posterior intermediate tubercle.

The characters of the upper true molars of *Protapirus obliquidens* are nearly the same as those of Tapirus; their peculiarity is the obliquity of the external lobes and also of the posterior crest. The lower jaw of the American Lower Miocene Tapir is nearly as large as that of the Brazilian Tapir. The inferior premolars, like the upper, are simpler in structure than those of the recent Tapir; this applies especially to the posterior crest, which is undeveloped. We find that the last lower true molar has lost the large third lobe so characteristic of the Eocene Tapirs of America.

The foot structure of the American species of *Protapirus* shows that it is nearly identical with the recent form. In contrast with the Brazilian Tapir we notice the greater size of the fifth toe in comparison with the middle digit. The elements of the carpus are much displaced in *Protapirus*, and only differ from the recent Tapir in their rather more elongated form.

One of the contemporaries of Protapirus in the Lower Miocene of America is the genus *Colodon* (*Mesotapirus*, S. & O.). This Tapiroid resembles *Protapirus* somewhat in the structure of its teeth, but in the lower jaw the external incisor is absent. We can readily distinguish between the true Tapirs and the pseudo-Tapirs of the Lower Miocene by the form of the postero-external lobe of the superior molars, as already described. The structure of the manus of *Colodon* differs considerably from that of *Protapirus*. In the former genus the fifth digit is very small, and there is some enlargement of the middle digit. In fact the structure of the manus in this genus proves that it was tending towards monodactylism; this is also shown from the reduced size of the ulna as compared with the size of the radius. Phylogenetically *Colodon* is now considered to be the outcome in the Miocene of the Bridger (Eocene) genus *Helaletes*.

In *Tapiravus*, Marsh, from the Pliocene the last two premolars

are as complex as the molars. Prof. Marsh considers this form closely related to the recent Tapir and standing in ancestral relationship to it.

The distribution of the genus Tapirus in Post-Pliocene times in America appears to have been very general, and remains of Tapirs are recorded from many of the Southern and Western States.

In conclusion, we may summarize the following points in the evolution of the Tapir, and the relationship between the American and European species of *Protapirus*: 1. True Tapirs make their first appearance in America in the Lower or White River Miocene; this formation is higher stratigraphically than that in which *Protapirus* (*P. priscus*) occurs in Europe.

2. The American species, *Protapirus obliquidens*, is in about the same stage in the evolution of its premolars as that of the *P. Douvillei* from St. Gérand-le-Puy in France.

3. *Protapirus priscus* of the Phosphorites is a much higher developed type than its probable contemporary in America, namely, *Isectolophus annectens*.

4. In contrast with the other Perissodactyla of the White River formation, the premolar teeth of *Protapirus* are simple in structure, and have not assumed the pattern of the true molars as in the recent Tapir.

5. We cannot agree with M. Filhol, that the genus *Protapirus* is the same as the American genus *Hyrachyus*. We believe these genera are entirely distinct.

III.—The Pre-Cambrian Rocks of Wales.[1]

By Henry Hicks, M.D., F.R.S., F.G.S.

In a recent article on the Pre-Cambrian Rocks of the British Isles in the Journal of Geology, vol. i., No. 1, Sir Archibald Geikie makes the following statement: "There cannot, I think, be now any doubt that small tracts of gneiss, quite comparable in lithological character to portions of the Lewisian rocks of the North-West of Scotland, rise to the surface in a few places in England and Wales. In the heart of Anglesey, for example, a tract of such rocks presents some striking external or scenic resemblance to the characteristic types of ground where the oldest gneiss forms the surface in Scotland and the West of Ireland." To those who have followed the controversy which has been going on for nearly thirty years between the chiefs of the British Geological Survey and some geologists who have been working amongst the rocks in Wales, the importance of the above admission will be readily apparent; but as it is possible that some may be unable to realize what such an admission means in showing geological progress in unravelling the history of the older rocks in Wales during the past thirty years, a brief summary of the results obtained may possibly be considered useful. It is now twenty-nine years since it was announced by Mr. Salter (at the meeting of the British Association, 1864) that during researches

[1] Paper communicated to the Geological Congress, Chicago, August, 1893.

carried on by him in conjunction with myself at St. Davids, in Pembrokeshire, we had found "that the mass of igneous rock which forms the backbone of the St. Davids peninsula, and which supports, without penetrating them, the shallow water accumulations of the older Cambrian around it," was a "part of the old Pre-Cambrian land," and that "as the purple rocks, sandstones, and slates of the whole Lower Cambrian division are thrown up at high angles, all but vertical on either flank of this mass, which forms the axis of the whole country, there is no difficulty in studying its behaviour in contact with the Cambrians." Moreover, it was stated that "if it were an intrusive trap of later date it would penetrate them here and there, or at least alter them at the point of contact. On the contrary, wherever the boundary can be seen, steatitic and felspathic schists unaltered, and beds of thick conglomerate mark the line and are often very conspicuous. These conglomerates of quartz rock, jasper, felstone, etc., may or may not have been derived from the immediate neighbourhood. They are traceable along the south and north sides of the trap region, and are followed by sandstones of various degrees of coarseness, but indicating by the ripple-mark, as well as the coarse material, that they were accumulated in shallow water; and as we know that pebbles often as large as swans' eggs, are not carried far out to sea, but mark either a submarine shoal or a coast-line, we are compelled to assign them to a source near at hand."[1] The above remarks (Brit. Assoc. Report and Geol. Mag. 1864) were written as already stated twenty-nine years ago, and the evidence since obtained has confirmed in a marked degree the main conclusions we then arrived at. The great mass referred to was then, and still remains, marked on the map of the Geological Survey as syenite and felstone, chiefly of Lower Silurian age. The view put forward by Mr. Salter and myself that it was of Pre-Cambrian age was, as is well-known, most strongly opposed by the chiefs of the Geological Survey, and up to a very recent period they

[1] The basal Cambrian conglomerates at St. Davids, which in places are over a hundred feet in thickness, often contain very large pebbles. This day (Aug. 17th) I measured two well-rounded blocks at the base of the conglomerate where it rests on the upturned edges of the Pebidian strata at Whitesand Bay, which gave the following dimensions:—

Quartzite pebble with a slightly purplish tinge, 18 inches in length, 12 in width, and 9 in thickness. Quite near to the above was a well-rolled block of vein quartz, 17 inches in length, 16 in width, and 11 in thickness. On the same face dozens of pebbles 6 to 8 inches across were also visible; and amongst them were numerous somewhat smaller pebbles of slaty and compact volcanic ash, porcellanite, schistose felstone, etc., which had undoubtedly been derived from the underlying Pebidian rocks. The enormous quantity of quartzite, and the frequent presence of fragments of quartzose schists, in the conglomerate prove clearly that there must be a hidden ridge of such rocks (Arvonian) near at hand. The quartz-grains and bits of felspar which formed these quartzites and schists were primarily derived fram Granitoid rocks (Dimetian), such as are now seen at St. Davids, and on the coast at Poulthikey. In addition, therefore, to showing the marked unconformity on the Pebidian, these conglomerates yield indisputable proof of the exposure of three Pre-Cambrian groups in the St. Davids area when they were deposited. No amount of ingenious argument can alter these facts, and the evidence is perfectly clear to those who desire to reach it.

have persistently denied that there were any Pre-Cambrian rocks i Wales. Further researches in other districts in Pembrokeshire an in North Wales enabled me to announce that there was evidence t show that several other great masses of igneous rocks shown o the maps of the Geological Survey as intrusive in Cambrian an Lower Silurian strata, were in reality portions of a Pre-Cambria land which had been forced up by great earth movements and after wards exposed to view by denuding agencies. This mass at S Davids and others of a like nature in Anglesey and Carnarvonshir had been credited by the Geological Surveyors with producing marke metamorphic changes in the rocks which surrounded them, so tha large areas in their immediate neighbourhood were coloured a metamorphosed Cambrian and Silurian strata. These so-calle metamorphosed rocks, as will be explained further on, I was abl subsequently to show to be mainly volcanic rocks of Pre-Cambria age. The igneous rocks in Wales, which are now admitted to b of Pre-Cambrian age by the majority of the geologists who hav examined them, are marked on the Geological Survey maps either as syenite, granite, felstone or felspathic porphyry. These masses subsequent to their consolidation, have been freely traversed by dykes of acid and basic igneous rocks, and the signs of alteration which are occasionally seen are due to contact with these dykes. Some of the dykes are undoubtedly of Pre-Cambrian age, and they show clear indications of having suffered from the movements which affected the rocks in Pre-Cambrian times; others are of more recent date, and traverse both the Pre-Cambrian and the overlying series. Igneous rocks of somewhat similar character to some of the masses now classed as of Pre-Cambrian age may be recognized here and there as having been intruded into Cambrian and Lower Silurian strata; but these do not show evidence of having been crushed or foliated to anything like so marked a degree as the similar rocks of Pre-Cambrian age. To the granitoid rocks (massive and gneissose), in the year 1877, I gave the name "Dimetian," and I classed them as the oldest of the Pre-Cambrian rocks in Wales. They are in fact the rocks which Sir Archibald Geikie now says are "quite comparable in lithological character to portions of the Lewisian rocks of the North-West of Scotland." It is important to note that in our earlier papers we classed these masses, as we do now, as of igneous origin, maintaining that they were of Pre-Cambrian age, and not intrusive in the Cambrian and Lower Silurian strata; but unfortunately the extravagant views subsequently in vogue in regard to questions of metamorphism led us, like others, for a time to believe that it was possible that even some of these massive crystalline rocks might originally have been sedimentary strata. When the microscope, however, was more freely used in their examination, it became apparent that they could not at any time have been sediments, and Professor Bonney, Mr. T. Davies, Dr. Callaway, Mr. Teall, and others have now clearly demonstrated that they are in the main igneous bosses, some still retaining their massive character though showing indications of having been much

crushed, others assuming a schistose or gneissose appearance as the result of pressure and metamorphism. I have readily admitted in previous papers that since these rocks have been proved to be of igneous origin they cannot have the same value for purposes of classification as when they were supposed to be metamorphosed sediments; but on the other hand it is clear that they are older than the quartzites and other sediments of Pre-Cambrian age which frequently contain fragments derived from them. At the meeting of the British Association in 1878, I announced for the first time that I had obtained evidence to show "that the so-called intrusive granites in Anglesey and the whole of the area marked as altered Cambrian in that island" were of Pre-Cambrian age. I classed the rocks there under three names as follows:—

Dimetian, to include the granitoid rocks and gneiss.

Arvonian, the schistose and compact quartz rocks and some felsites and porphyries.

Pebidian, green and purple agglomerates and breccias, green chloritic schists, with massive greenstone bands, talcose schists, etc.

In the previous year, 1877, Prof. Hughes and I, in separate papers, had pointed out that there were masses of granitoid rocks and of quartz felsites in Carnarvonshire, which had every appearance of being older than any of the Cambrian rocks. It was stated that they resembled in a marked degree some of the Pre-Cambrian rocks of Pembrokeshire, and that as in that area they were flanked by unaltered Cambrian sediments. The volcanic series in Pembrokeshire, in Carnarvonshire, and in Anglesey we placed as the highest group, and we showed that the overlying Cambrian conglomerates reposed transgressively on, and contained large pebbles derived from, beds belonging to that series. We have since shown that the Cambrian conglomerates in reality are made up of fragments derived by denudation from the three series referred to, and that an important interval must have elapsed between the upturning of the beds, even of the latest of the Pre-Cambrian series, and the deposition upon them of the basal Cambrian conglomerates.

In the paper already referred to Sir Archibald Geikie says that the schists, quartzites and limestones in Anglesey present a close resemblance to the Dalradian series of Scotland and Ireland "and that the coarse gneiss" may be compared, in general character, with parts of the Lewisian rocks, so that we seem to have here, as in Ireland, two groups of schistose rocks, and both of these much older than the unaltered Cambrian strata which lie above them. I have already stated that the oldest group, "coarse gneiss," above referred to was mapped by the Geological Surveyors as granite intrusive in Cambrian and Silurian strata, and that no suspicion that it was of Pre-Cambrian age was entertained until the year 1878, when I pointed out that it resembled in a marked degree the "Dimetian" of St. Davids, and stated that I had obtained evidence to show that it was not intrusive in the surrounding rocks. At first I associated the "quartzose rocks" with the "Dimetian," but afterwards placed them in a newer group "Arvonian," and in this group I included the

"schistose and compact quartz rocks, breccias, halleflintas, an quartz-felsites" of Holyhead Mountain, Bodafon Mountain, an Ty Croes, in Anglesey. This group, therefore, was made to includ the majority of the rocks now stated by Sir Archibald Geikie t have a close resemblance to the "Dalradian series" of Scotland and the term "Arvonian" should therefore be retained for them The next group in Anglesey, the "Pebidian," is mainly a volcani series, but it contains also many beds of clastic origin. Sir Archibal Geikie says that he regards the so-called Pebidian "as merel marking the duration of a volcanic period in early Cambrian time.

Other British geologists, including Prof. Hughes, Prof. Bonney Dr. Callaway and Mr. Blake, who have examined these rocks a St. Davids and in Anglesey, are satisfied that they are of Pre Cambrian age and that I correctly assigned them to that horizo when I first described and classed them as a group under the nam "Pebidian." As the so-called "Dalradian series" has been re ferred to for purposes of comparison with some of the Anglesey rocks, it may be well to state what the term "Dalradian" was a first intended to include. In his address to the Geological Societ in 1891, when the name was first used, Sir A. Geikie said, "I hav myself no doubt that the rocks are far more ancient than any tha could be classed as Lower Silurian, though it is of course conceivabl that portions of even Lower Silurian strata have been caught i their plications and have undergone metamorphism. If they ar claimed as Pre-Cambrian, I am not aware of any better proof tha can be furnished against than in favour of such a claim. They ma possibly include equivalents of the Torridon Sandstone as well a the Durness groups, and even portions of the upthrust Archæa platform." He further states that "Such a name need not be permanent addition to geological terminology, but it might, at leas for some time, be usefully adopted as a convenient epithet until th true stratigraphical position of the rock is definitely ascertained."

Now that Sir A. Geikie has satisfied himself as to the clos resemblance of the Pre-Cambrian rocks in Anglesey with the so called "Dalradian" of Scotland, the time appears to me to hav arrived when that term should be dropped or not further used whe reference is made to the crystalline schists of the Central Highlands which I classed in the year 1880 (eleven years before the term Dalradian was employed by Sir A. Geikie) as a Pre-Cambrian group under the far better and more distinctive term "Grampian." The Pre-Cambrian rocks of Wales, therefore, according to the most recen views, resolve themselves into three well marked groups, and the chronological order is that in which I placed them in the years 187 and 1878. Some rocks, owing to our having since obtained mor satisfactory evidence of their position, have been removed from one group and placed in another; and in some few instances have been removed from the groups. Such changes, which necessarily must occur with improved knowledge, do not in any way warrant the adoption of new names for groups which still show the main distinctive characters under which they were first described.

The rocks in Wales classed as Dimetian, Arvonian, and Pebidian may or may not be equivalents of the rocks in Scotland called by the names Lewisian, Grampian, and Torridonian; but at present it is far safer and certainly fairer that the groups should retain the names given to them in the country where their positions were first recognized.

IV.—The Geological Development, Descent and Distribution of the Mammalia.[1]

By Prof. Karl A. von Zittel, Ph.D., For. Memb. Geol. Soc. Lond.
Professor of Palæontology in the University of Munich.

In a spirited treatise on the 'Origin of our Animal World' Prof. L. Rütimeyer,[2] in the year 1867, described the geological development and distribution of the mammalia, and the relationship of the different faunas of the past with each other and with that now existing. Although, since the appearance of that masterly sketch the palæontological material has been, at least, doubled through new discoveries in Europe and more especially in North and South America, this unexpected increase has in most instances only served as a confirmation of the views which Rütimeyer advanced on more limited experience. At present, Africa forms the only great gap in our knowledge of the fossil mammalia; all the remaining parts of the world can show materials more or less abundantly, from which the course followed by the mammalia in their geological development can be traced with approximate certainty.

Mesozoic Era.

The oldest remains of mammals come from the Triassic rocks. Detached teeth of *Microlestes* and *Triglyphus* from the Rhætic beds of Würtemberg and England, a skull of *Tritylodon* and skeletal fragments of *Theriodesmus* from the Karroo beds of South Africa, prove the wide distribution of the unfortunately still very imperfectly known Allotheria at the beginning of the Mesozoic period. If it is at present not yet possible to indicate the settled position of these small plant-eating or omnivorous animals in the zoological system, it yet remains certain that they can only be compared with the lowest organized of existing mammals, the Monotremata and Marsupialia; and neither in their dentition nor in the form of the skull do they show relations to Reptilia or Amphibia. Quite another group of primitive mammalia of small dimensions is indicated by two small lower jaws from the upper Trias of North Carolina. The genera *Dromatherium* and *Microconodon* remind one of Insectivora and Marsupialia, but they differ from both in the highly primitive

[1] Translated, with the permission of the author, by Dr. G. J. Hinde, V.P.G.S., etc., from the German, Aus den Sitzungsberichten der mathematisch-physikalischen Classe der k. bayer. Akad. d. Wiss. 1893. Bd. xxiii. Heft. II. pp. 137–198. The present treatise forms the concluding chapter of the 4th volume of the author's Handbook of Palæontology, Munich, R. Oldenbourg, 1893.

[2] Rütimeyer L. Ueber die Herkunft unserer Thierwelt. Eine zoogeographische Skizze. Basel. 1867.

triconodont molars, in which the crown is not sharply separated from the root, which is simple, or only incompletely-divided by a lateral furrow. The slender styliform incisors and powerful canines show further that the Triassic Protodonts of America possessed a not less differentiated dentition than the Tritylodontidæ from Europe and South Africa.

In the Jurassic period both the Allotheria and the insect-eating Marsupials increased and became further developed. The Great Oolite of Stonesfield and the Purbeck 'Dirt-bed' are still the only localities in Europe in which they have been found, but besides these the Upper Jurassic "Atlantosaurus Beds" in Wyoming and Colorado have yielded a wealth of new forms, which, however, like their European contemporaries, are mostly represented by jaws and small detached teeth, and very seldom by other bones of the skeleton. The Jurassic Allotheria are divided into two families, as yet very insufficiently characterized; of these, one (Bolodontidæ) is only represented by upper jaws; the other (Plagiaulacidæ) principally by lower jaws. In the structure of the molars these last agree with the Triassic *Microlestes*, but the lower premolars possess the form of cutting, laterally-grooved, blades, like those now only present in the grass-eating Kangaroo-rats (Hypsiprymnidæ). The rodent-like incisors also admit of comparison with those of *Hypsiprymnus* and other Diprotodont Marsupials. The circumstance is of interest that up to the present only two genera (*Plagiaulax* and *Bolodon*) are known from the Purbeck beds of England, and that North America possesses two nearly related representative forms in *Ctenacodon* and *Allodon*. Of the minute *Stereognathus* from the Great Oolite of Stonesfield with crescent-shaped tubercles on the molars, only a single jaw is known.

Besides the Allotheria, there are in the Jurassic strata of Europe and North America a considerable number of genera having molars with three pointed cusps, conical canines, and styliform or spatulate incisors, which seldom exceeded a rat in size and mainly lived on insects. The European forms were all placed by Owen with the Polyprotodont Marsupials and compared with the living *Myrmecobius*, but it is only in certain genera in which the dentition and form of the jaw exhibit such plainly marked marsupial characters, that their position can be certainly determined; in many instances a mingling of the peculiarities of Marsupials and Insectivora renders a decision impossible. Marsh solved the question in a radical manner by placing the Mesozoic mammals with pointed teeth in an independent order, *Pantotheria*; Osborn recognises in them the ancestors of the Polyprotodont Marsupials and of the Insectivora. Unfortunately our knowledge of these ancient mammals depends at present entirely on jaws, isolated teeth, vertebræ, and some rare bones of the extremities. No pelvis with the characteristic marsupial bones has, as yet, been discovered. As in the Allotheria, so also in the Jurassic Polyprotodonts there is an astonishing similarity, and in some instances, even complete resemblance between the European and American genera. In the following list the corresponding

genera on both continents are placed opposite each other, and those from the English Great Oolite are indicated by (G. O.) and those from the Purbeck by (P.).

England.	North America.
Amphilestes (G. O.)	*Priacodon.*
Triconodon (P.)	*Triconodon.*
Phascolotherium (G. O.)	
Spalacotherium (P.)	*Tinodon.*
	Dicrocynodon.
	Docodon.
	Ennacodon.
Amphitherium (G. O.)	
Peramus (P.)	
Amblotherium (P.)	*Paurodon.*
Achyrodon.	*Laodon.*
	Dryolestes.
	Asthenodon.
Curtodon (P.)	

The Jurassic Mammalia have been formerly supposed to bear an Australian facies; but a comparison of the existing Marsupials of Australia with the Jurassic Allotheria and Pantotheria shows, however, only very limited points of connection between them. The Mesozoic forms exhibit a much more uniform character than their more strongly differentiated Australian relations, and the main agreement of the two faunas consists in the absence of placental genera.

No traces of Mammalia were known from the Cretaceous formation until the year 1882. Now, isolated teeth of the genus *Plagiaulax*, already known in the Jurassic, have been found in the English Wealden, and from the so-called Laramie-beds of Western America a notable number of teeth and fragments of jaws have been described by Marsh. The hopes which had been earlier entertained of the discovery of Cretaceous Mammalia, have not been altogether fulfilled, for those which have been found up to the present indicate that the Jurassic forms had passed through but slight changes in the Cretaceous Epoch, and that Allotheria, Pantotheria, and perhaps a Tillodont-genus (*Stagodon*) still constituted the primitive stock of the Mammalian fauna of this period. The expected precursors of the Ungulates, Carnivora, Rodents, and other placental orders have not been discovered. The numerous genera founded by Marsh on detached teeth have been greatly reduced by Osborn; the, in some measure, well-grounded forms, such as *Meniscoëssus*, *Cimolomys*, *Allacodon* and *Oracodon* are closely connected with the Jurassic *Allotheria*, or, such as *Dryolestes* and *Pediomys*, with the Pantotheria. Some small jaws and teeth referred to *Didelphops*, *Cimolestes*, *Telacodon* and *Batodon* appear to be genuine Marsupials (Didelphyidæ). Thus the diminutive forms of the Cretaceous Mammalian fauna appear to be an extension of the Jurassic and not the forerunners from which the infinitely richer and more varied Tertiary fauna can be traced.

With the beginning of the Tertiary era the sources of our knowledge of fossil Mammalia are much more abundant than in the Mesozoic period.

I. Lowest Eocene.

Already in the intercalated fresh-water beds in the neighbourhood of Rheims, belonging to the Lowest Eocene, a very remarkable fauna has been discovered by Lemoine.[1] Only the genera *Neoplagiaulax* and *Liotomus* are linked to the Allotheria of the Upper Chalk, the remaining constituents of the "Fauna of Cernays" belong to the Placental mammalia. Small Insectivora (*Adapisorex*) and Carnivora (*Creodontia*) of a very primitive type (*Procynictis, Dissacus, Hyænodictis, Tricuspiodon, Arctocyon, Conaspidotherium, Arctocyonides, Plesiesthonyx, Protoproviverra*), which, indeed, with the exception of the prominently large *Arctocyon*, are only represented by very scanty remains; further, some five-toed ungulates of the order Condylarthra (*Pleuraspidotherium, Orthaspidotherium*), and two doubtful Lemurs (*Plesiadapis* and *Protoadapis*) compose this oldest Tertiary assemblage of animals in Europe.

A remarkably similar contemporaneous fauna comes from the "Puerco-beds" of New Mexico. According to Cope[2] the vertebrate fauna of Puerco consists of twelve species of reptiles, one of birds, and ninety-three of mammals. Of these last, no fewer than 45 belong to the Creodontia (*Mioclænus, Tricentes, Chriacus, Protochriacus, Oxyclænus, Pentacodon, Goniacodon, Sarcothraustes, Deltatherium, Triisodon, Dissacus, Didymictis*, and others), 24 to the Condylarthra (*Haploconus, Anisonchus, Zetodon, Hemithlæus, Periptychus, Ectoconus, Protogonia*), 2 to the Amblypoda (*Pantolambda*), 5 to the Lemurs (*Mixodectes, Indrodon*), 7 to the Tillodontia (*Psittacotherium, Hemiganus, Conoryctes, Onychodectes*), and 11 to the Allotheria, amongst which the genus *Polymastodon*, is much larger than the associated genera *Neoplagiaulax, Ptilodus* and *Chirox*. The more varied composition of the American fauna corresponds with its greater abundance, but the only new order not present in the European fauna is the Tillodontia, and this is probably already represented in the Upper Chalk by the genus *Stagodon* (Thlæodon). If we review, as a whole, the mammals from Rheims and Puerco, we find, together with certain Allotheria continued from the Chalk (which here reach their maximum and then disappear finally), and together with the puzzling Tillodontia, which die out in the Eocene, four different orders of Placental mammals (Creodontia, Condylarthra, Amblypoda, Pachylemuria). The typical representatives of these four orders in the Newer Eocene, where they first attain their complete development, stand, in external appearance and in their general organization, far from each other; the forms from the faunas of Cernays and Puerco, on the other hand, are connected together so closely by a number of features in common, that in many instances it is difficult to decide to which order they may belong. They all possess five-toed planti-

[1] Lemoine, V. Étude d'ensemble sur les dents des Mammifères fossiles des environs de Reims. Bull. Soc. Géol. de France, 1891, 3 ser. xix. pp. 263–290.

[2] Cope, E. D., Synopsis of the Vertebrate Fauna of the Puerco Series. Trans. Amer. Philos. Soc. 1888, xvi.

grade extremities, of which the terminal phalanges are provided neither with genuine hoofs nor with real claws, but with a something intermediate between both; in all, the bones of the fore-arm and foot remain separate; the humerus is nearly always penetrated by an entepicondylar foramen; the femur has a third trochanter and a *centrale* was present in the carpus of most, probably of all the forms. The skulls, generally, have a depressed, longitudinally-extended form; strongly developed facial-bones, a diminutive brain-case, smooth cerebral hemispheres, which do not project over the cerebellum. There is, further, no very notable differentiation in the dentition. The incisors and canines are conical, the premolars are simple, and the brachyodont molars in the upper jaw tritubercular, and in the lower "tritubercular-sectorial." If it were possible to breathe life again into the animals of the Cernays and Puerco period, and to transplant them amongst the existing mammalian fauna, any zoologist would be very likely to group the Creodontia, Condylarthra, Pachylemuria, and Amblypoda of that period together into one single order, although they undoubtedly represent the primitive forerunners of four, subsequently strongly-differentiated, groups. This growth of different stems from a common root, forms one of the strongest arguments in favour of the descent-theory, although it is also at the same time no small difficulty in the way of classification. If the Older Eocene mammals had not been further developed and differentiated, we should probably have distinguished only two orders of Placental mammals, of which one would be the Tillodontia, and the other would include all the remaining forms.

Already in the succeeding zone of the Older Eocene, to which in Europe the London Clay of England, the Lower Sand, the Plastic Clay and Lignite of the Paris basin, belong, as well as also the so-called Wasatch or Coryphodon beds of Wyoming, Utah and New Mexico, in North America, the character of the Mammalian fauna has not inconsiderably been changed. The Allotheria have disappeared. The Creodontia have much increased in size, and are greatly differentiated, and they have already received a carnivorous stamp. Amongst the Ungulates, Amblypoda, Condylarthra, and the Perissodactyla are very distinctly separated; there are some rare and primitive forerunners of the Artiodactyla; the Prosimiæ (Pachylemuridæ) are numerous, and the Rodents and Tillodonts are represented by typical and strongly-differentiated genera. The genera of this horizon, known up to the present, are distributed in Europe and North America, as follows:—

CONDYLARTHRA.

EUROPE.	NORTH AMERICA.
†*Phenacodus.*[1]	**Phenacodus.**
†*Protogonia.*	*Protogonia.*
†*Meniscodon.*	**Meniscotherium.**
†*Periptychus.*	*Hyracops.*

[1] The forms thus marked (†) are known only from the Bohnerz of Switzerland; those printed in thick type are the specially characteristic and most numerously represented genera.

Europe.	North America.
PERISSODACTYLA.	
Hyracotherium.	**Hyracotherium.**
Pachynolophus.	*Pachynolophus.*
Lophiodon.	*Eohippus.*
Brachydiastematotherium.	*Heptodon.*
	Systemodon.
	Lambdotherium.
ARTIODACTYLA.	
Lophiodochœrus.	*Pantolestes.*
Protodichobune.	
AMBLYPODA.	
Coryphodon.	**Coryphodon.**
	Manteodon.
	Ectacodon.
TILLODONTIA.	
Esthonyx.	**Esthonyx.**
(*Platychœrops.*)	**Calamodon.**
†*Calamodon.*	*Stylinodon.*
	Dryptodon.
	? *Ectoganus.*
RODENTIA.	
Decticadapis.	*Paramys.*
INSECTIVORA.	
Adapisoriculus.	*Diacodon.*
	Centetodon.
CREODONTIA.	
Palæonictis.	**Palæonictis.**
†**Proviverra.**	**Oxyæna.**
†*Cynohyænodon.*	*Amblyctonus.*
†*Ailuravus.*	**Pachyæna.**
? *Argillotherium.*	*Anacodon.*
	Sinopa.
	Didelphodus.
	Dissacus.
	Miacis.
	Didymictis.
PROSIMIÆ (PACHYLEMURIDÆ).	
†*Pelycodus.*	**Pelycodus.**
†*Hyopsodus.*	**Hyopsodus.**
	Lemuravus.
	Microsyops.
	Tomitherium.
	Anaptomorphus.
	Mixodectes.
	Cynodontomys.
	? *Sarcolemur.*
	? *Apheliscus.*
	? *Opisthotomus.*

If we compare with each other the Mammalian faunas living in the Older Tertiary period in these widely separated regions, we are at once struck by the contrast of the poverty in genera and species of the European region with the abundance in the American localities. If we consider, however, that the few areas in Europe yielding the materials of this fauna are of very limited extent in Northern France, England and Switzerland, whilst in Wyoming,

Utah and New Mexico the Older Tertiary fresh-water beds cover hundreds of square miles and are quite open to investigation, we need not relinquish the hope of future fresh discoveries in Europe. The excellent researches of Rütimeyer[1] on the Bohnerz fauna of Switzerland have moreover shown that during the Eocene period an unexpected number of genera of a distinctly American stamp lived in Europe. The fissures in the Jurassic Limestones filled with mud and ferruginous-concretions (Bohnerz), in which these forms were preserved, cannot be directly compared with ordinary sedimentary strata. Their infilling was probably a very slow process; it plainly began during the Older Eocene period and continued to its close. The Bohnerz fauna of Switzerland has, therefore, no individual character; forms of Old-Eocene type are mingled in it with those of the Middle and Upper Eocene. The earlier forms are, as a rule, only indicated by a few isolated teeth, but they nevertheless serve to show that several genera, hitherto held to be indigenous to America, lived also in Europe. And this fact is of great importance, since it proves not only the unity of origin of the Older Eocene fauna, but also the former connection of two regions of distribution, now sharply separated.

II. Middle Eocene.

The conditions of preservation were still more unfavourable in Europe during the Middle Eocene than previously. The neighbourhood of Paris, the fresh-water deposits of Argenton (Indre), Bracklesham (Sussex), Issel (Aude), Buchsweiler (Alsace), and some few other scattered localities have yielded the scanty remains of a mammalian fauna, amongst which may be named the Perissodactylous genera *Lophiodon*, *Palæotapirus*, *Propalæotherium*, *Paloplotherium*, *Hyracotherium*, *Pachynolophus*, *Pernatherium*, the Artiodactyle *Dichobune* and the Creodont genus *Proviverra*. The teeth and fragmentary bones and jaws which have been washed together into the Bohnerz fissures of the Swiss Jura at Egerkingen, Gösgen, Mauremont and St. Loup, would have better revealed the composition of the Middle Eocene mammalia, if they had not contained a commingling of remains from all the other divisions of the Eocene period. A comparison with the American area, where the renowned Bridger or *Dinoceras*-beds of Wyoming are filled with beautifully preserved mammals, is beset with great difficulty for want of material. Fresh finds in Europe may yet yield further forms of an American type, since all our Middle Eocene genera possess in the Bridger beds, either representative forms or are themselves directly represented by slightly different species. The Bridger beds contain the following genera:[2]

Marsupialia.	*Eohippus.*	*Lambdotherium.*
Didelphys.	**Pachynolophus.**	**Helaletes.**
	(*Orohippus.*)	**Hyrachius.**
Perissodactyla.	*? Helohippus.*	*Colonoceras.*
Hyracotherium.	*Epihippus.*	*Triplopus.*

[1] Die eocäne Säugethierwelt von Egerkingen. Abh. Schweiz. paläon. Gesellsch. 1891, Bd. xviii.

[2] The Genera most numerously represented are printed in thick type.

PERISSODACTYLA.
Amynodon.
Palaeosyops
Limnohyops.
Telmatotherium.

ARTIODACTYLA.
Achænodon.
Homacodon.
? *Oromeryx.*
Ithygrammodon.
? *Stibarus.*

AMBLYPODA.
Uintatherium.
Dinoceras.
Loxolophodon.
(*Tinoceras.*)

TILLODONTIA.
Tillotherium.
Anchippodus.

RODENTIA.
Paramys.
Mysops.
Tillomys.
Toxymys.
Colonymys.

INSECTIVORA.
Ictops.
? *Passalacodon.*
? *Anisacodon.*
? *Entomacodon.*
? *Euryacodon.*

CHIROPTERA.
Nyctilestes.
Vesperugo.
Nyctitherium.

CREODONTIA.
Mesonyx.
Proviverra.
Protopsalis.
Miacis.
Didymictis.

PROSIMIÆ.
Hyopsodus.
Tomitherium.
Omomys.
Notharctus.
Limnotherium.
Microsyops.
? *Thinolestes.*
? *Telmatolestes*, etc.

In the Middle Eocene also appear the first marine Mammals, for instance, *Zeuglodon* in North America and Europe, *Halitherium* in Europe and North Africa, and *Prorastomus* in the West Indies. The characteristic features of the Middle Eocene fauna are the great development of the Perissodactyla and the Prosimiæ, and the sudden appearance of the mighty Dinoceratidæ, at present limited to North America. The Artiodactyla, Rodents and Insectivora continue to increase, the Creodontia and Tillodontia are already on the decline, whilst the Chiroptera are known for the first time.

III. Upper Eocene.

In the first rank of the Upper Eocene may be reckoned the renowned fauna of the Paris gypsum-beds described by Cuvier. (By many authors it is also placed as Lower Oligocene.) Contemporaneous with this are the lignite deposits, rich in mammals, of Débruge near Apt (Vaucluse); the freshwater marls and chalky-beds of Alais and St. Hippolite (Gard), of the neighbourhood of Le Puy in Velay, and of Castelnaudary (Languedoc); of the Upper Rhine Valley (Mühlhausen, Alsace, Breisgau in Baden) and the freshwater-beds of Bembridge and Hordwell in the South of England. Numerous remains of the same fauna have been inclosed in the Bohnerz of the Swiss, Swabian and Franconian Jura (Egerkingen, Gösgen, Mauremont, Delsberg, Moutiers, Schaffhausen, Fronstetten; around Ulm, Heidenheim, Pappenheim, and other places), and, more especially, in the phosphate-bearing loam which fills the Jurassic fissures in the so-called Quercy, between Villefranche and Montauban. As already remarked, the Bohnerz and Phosphate-beds do not contain one particular fauna: in Switzerland (particularly near Egerkingen and Mauremont) there is a mingling of Old Eocene species with those from the Middle and Upper Eocene; at Quercy there is a small percentage of genuine Oligocene, and even of Lower Miocene types, associated with the Upper Eocene forms. Although, therefore, the Phosphorites contain an altogether preponderant number of Upper Eocene species, and tolerably all the Upper Eocene genera occurring elsewhere, and though, in the

abundance and beautiful preservation of the remains they throw into the shade all other Upper Eocene localities, yet, in forming a judgment on the general characters of the fauna, the remains from beds deposited in a normal manner must chiefly be taken into account.

The Upper Eocene fauna in Europe includes the following genera:[1]

MARSUPIALIA.
Didelphys.

CONDYLARTHRA.
†*Phenacodus.*
†*Protogonia.*
†*Periptychus.*
†*Meniscodon.*

PERISSODACTYLA.
†? *Hyracotherium.*
*†*Pachynolophus.*
Lophiotherium.
†**Propalæotherium.*
Palæotherium.
Paloplotherium.
Anchilophus.
†**Lophiodon.*
**Protapirus.*
***Cadurcotherium.**
**Aceratherium* (M.)
**Schizotherium.*
**Limognitherium.*

ARTIODACTYLI.
**Anthracotherium* (O.)
Ancodus.
*†*Rhagatherium.*
**Tapirulus.*
**Elotherium* (O.)
Cebochœrus.
**Hemichœrus.*
Acotherulum.
**Doliochœrus.*
Chœropotamus.
**Palæochœrus* (M.)
Anoplotherium.
Diplobune.
Dacrytherium.
*? *Mixochœrus.*
Dichobune.
**Mouillacitherium.*
**Spaniotherium.*
**Oxacron.*
**Metriotherium.*
**Deilotherium.*
Xiphodon.
Amphimeryx.
Dichodon.
*†*Tetraselenodon.*
*†*Haplomeryx.*
**Tragulohyus.*
***Cœnotherium* (M.)
**Plesiomeryx* (M.)
Gelocus.
Lophiomeryx.
**Cryptomeryx.*
***Prodremotherium.**
**Bachitherium.*
**Choilodon.*
**Platyprosopos.*
**Dremotherium* (M.)

TILLODONTIA.
†*Calamodon.*

RODENTIA.
*†**Sciuroides.**
**Sciurodon.*
Sciuromys.
***Pseudosciurus.**
*†*Sciurus* (M.)
**Cricetodon* (M.)
*†*Trechomys.*
Theridomys (O. M.)
**Nesokerodon.*
**Protechimys.*
Myoxus (M.)
**Eomys.*
Plesiarctomys.
**Plesiospermophilus.*

INSECTIVORA.
**Myxomyogale.*
*†**Amphidozotherium.**
**Comphotherium.*
*†**Neurogymnurus.**
**Sorex* (M.)
**Necrosorex.*

CHIROPTERA.
***Pseudorhinolophus.**
**Alastor.*
**Vespertiliavus.*
**Necromantis.*
Nyctitherium.
(*Vespertilio*).

CREODONTIA.
*? *Adracodon.*
†*Mioclænus.*
**Quercytherium.*
Proviverra.
Galethylax.
†*Prorhizœna.*
**Oxyœna.*
Hyænodon (O. M.)
Pterodon.
**Pseudopterodon.*
**Thereutherium.*
†*Cynohyœnodon.*

CARNIVORA VERA.
(Fissipedia.)
Cynodictis.
*†**Cynodon** (O.)
**Plesiocyon.*
**Pachycynodon.*
**Amphicynodon* (O.)
**Cephalogale* (M.)
*†**Pseudamphicyon.*
*†*Brachycyon.*
***Stenoplesictis.**
***Palæoprionodon.**
**Haplogale* (M.)
**Stenogale* (M.)
***Plesictis** (O. M.)
Palæogale (M.)
**Amphictis* (M.)
Viverra (M.)
***Ælurictis.**
*†**Pseudælurus** (M.)
***Eusmilus.**

PROSIMIÆ.
Adapis.
***Necrolemur.**
Microchœrus.
**Heterohyus.*
**Cryptopithecus.*
†*Pelycodus.*
†*Hyopsodus.*

[1] The genera occurring in the Phosphate-beds only are marked with a *, those in the Swiss Bohnerz only with a †; those present both in the Phosphorites and the Bohnerz with *†. To the genera also occurring in the Oligocene an (O.), and to those in the Lower Miocene an (M.) is affixed. The specially abundant or characteristic genera are printed in thick type.

A comparison of this fauna (from which the genera from Egerkingen marked with † may properly be excluded) with that of the Lower and Middle Eocene of the same areas of distribution, shows a much greater abundance of genera (about 110) and species (about 200). Supposing that ten per cent. of the genera and species have only provisional value, and that they will disappear with more ample knowledge, there yet remains a varied and numerous company of animals such as to-day would only be met with in tropical regions. Our present European land mammalian fauna contains 54 genera with about 150 species, and of these about 60 per cent. belong to the microfauna consisting of the smaller forms of Rodents, Insectivora, Bats and Carnivora, for which the conditions of preservation in earlier epochs were very unfavourable. The Ungulates still play the leading part in the Upper Eocene, but the Perissodactyla have resigned their advanced position to the Artiodactyla. Amongst the former *Pachynolophus, Propalæotherium* and *Lophiodon* still continue, but they are inferior in number to the more modern genera *Palæotherium* and *Paloplotherium*. Amongst the Artiodactyla, nearly half the genera belong to the Anoplotheridæ, which in outer form approach nearest to the Perissodactyla, and in their dentition and build of the skeleton combine features of the Ungulata and Carnivora. They belong to the most peculiar creatures of that period. Their depressed lophodont molars call to mind the Palæotheridæ; no reduction of the canines or incisors is yet noticeable; horns or other protuberances are yet wanting on the skull; the extremities have undergone but very moderate differentiation, they always possess separated metapodials and inadaptive carpus and tarsus; and their terminal phalanges resemble the anomalous hoofs or claws of the Condylarthra. In outer form the Anoplotheridæ exhibit great variation. Whilst *Anoplotherium, Diplobune* and their relatives are similar to a Tapir, to which a very long tail has been added, *Dichobune, Xiphodon*, and others, call to mind slimly formed deer, and the delicate four-toed Cænotheriæ, which continued into the Miocene, varied in size between a Squirrel and a Cat. Next to the Anoplotheridæ, the Tragulidæ form the main contingent of the paired ungulates. Their dentition has almost attained the character of that of the brachyodont Ruminants, and in the structure of their skeleton and more especially of the extremities, they hardly remain behind the still existing Chevrotains, which in a certain measure, may be considered as relicts of an earlier epoch, since amongst all Ruminants they possess the most primitive features. The Eocene Suidæ (*Cebochœrus, Elotherium, Chœropotamus, Palæochœrus, Acotherulum*, etc.), bear the same relation to existing swine as the Tragulidæ to the Cervidæ. The crowns of their bunodont molars have four simple tubercles; canines and incisors, like those of the Condylarthra and Creodontia, are but little differentiated, and the skeleton has not undergone any simplification or reduction of the extremities worth mentioning. Also the early extinct Anthracotheridæ are shown to be collective types, which connect the lophodont and bunodont Artiodactyla with each other. The scarcity of the Condy-

larthra and Amblypoda shows moreover that the Upper Eocene Ungulates had already reached a higher development than those immediately preceding them, and this fact is also not less evident amongst the Carnivora. The more incomplete Creodontia are, so far as wealth of form is concerned, strongly on the decline, even though *Hyænodon* and *Pterodon*, yet belong to the most numerous and strongest Carnivores of that period. Near to these an abundance of genuine Fissipede Carnivora make their appearance, which are placed with the Canidæ, Mustelidæ, and Viverridæ, but they yet possess so many features in common, that they would certainly be united into a single family if they still lived in company with their more advanced and variously differentiated descendants of the present day. Only the Cats (*Pseudælurus*, *Eusmilus*) are already in the Eocene distinguished by sharply defined characters.

The Pachylemuridæ (*Adapis*, *Cænopithecus*, *Necrolemur*, *Microchœrus*, etc.) also form a very characteristic element of the Upper Eocene fauna; they are connected with Old Tertiary forerunners, and combine features of the existing Lemurs and genuine Apes.

The so-called micro-fauna is fairly abundantly represented by Rodents, Insectivora, Bats, and Marsupial Rats (Didelphys). The three last-named orders, anyhow, contain species without specially noticeable characteristics, so that they could very suitably still have existed, and they prove that since the beginning of the Tertiary period these groups have made but very little progress. The Rodents also form a very conservative element of the Upper Eocene group of animals. If in many points of differentiation they are behind their successors, they already possess every typical feature of the order, and they are hardly more closely connected with the representatives of other groups than their still existing descendants.

If we look round for materials for comparison with the Upper Eocene mammalia of Europe, it is to North America that we must at once again turn our view, where, resting on the richly fossiliferous Bridger beds, a filially related but impoverished fauna lies buried in the so-called Uinta or *Diplacodon* beds, in which the Amblypoda and Tillodontia have disappeared, the Perissodactyla (*Pachynolophus*, *Triplopus*, *Isectolophus*, *Diplacodon*, *Amynodon*), the Artiodactyla (*Protoreodon*, *Leptotragulus*), and the Creodontia (*Mesonyx*, *Miacis*), claim pre-eminence, and Rodents and Prosimiæ appear, at least, to be indicated by scanty remains. A detailed comparison of the contents of the Bridger and Uinta-beds with the Middle and Upper Eocene mammals of Europe would certainly yield a variety of parallels, but it would at the same time also show that common genera or representative members of the same group appear with less frequency than in the Older Eocene. Only a few names are repeated in the European and American lists (*Didelphys*, *Hyracotherium*, *Pachynolophus*, *Nyctitherium*, *Proviverra*), but on deeper search it would be found that several European genera turn up again in the Western hemisphere in a shallow disguise. Thus, for example, the genera *Helatetes* and *Isectolophus* take the place of the European *Lophiodon* and *Protapirus*; *Cadurcotherium* is replaced by *Amynodon*;

Plesiarctomys by *Paramys*; the European Lemurs, Bats, and Insectivora, for the most part have nearly related representative genera in North America, and for the Anoplotheridæ and Tragulidæ a substitute may be found in the altogether different Leptotragulidæ.

The development of the animals on both continents has evidently always followed different roads. The connection of the two continents appears, indeed, to have been still maintained, but the means of communication must have been difficult.

(*To be continued in our next Number.*)

NOTICES OF MEMOIRS.

I.—Western Australia. Report on the Murchison Goldfield. By Harry Page Woodward, F.G.S., etc., Government Geologist. 8vo. pp. 21. (Perth, 1893.)

THIS goldfield has a proclaimed area of 32,000 square miles. The principal auriferous belt is at its eastern side, about 200 miles from the coast, and has a general N. and S. direction. Other rich patches and belts occur further east (probably to a great distance), and a few nearer the coast. The metamorphic rocks constitute the base of this area, such as slates and schists, talcose, hornblendic, and micaceous, besides granite and highly altered ferruginous jaspery quartzites. These are traversed by large quartz-reefs, which are richest where intersecting the quartzite. There are also limestone beds, with veins of ferruginous calcite, bearing some gold. These rocks strike a little W. of N., dipping to the W., and in the northern part of the field turn N.E. and E., with granitic, dioritic, and other dykes.

On them lie remnants of an old table-land of the Mesozoic "Desert Sandstone" of Australia, consisting of horizontally bedded sandstones, clays, pipeclays, gypsum, and ferruginous layers. The alluvium in the water-courses, flats, and salt-marshes rarely exceeds 20 feet in thickness; there is also local travertine and other surface deposits. The alluvium has been derived largely from the Desert Sandstone, and partly from the metamorphic rocks; the latter *débris*, coarse and stony, sometimes overlies the former, because these older rocks were exposed to denudation after the Sandstones; hence the auriferous "wash" is not always on the true bottom; nor does it usually run in "leads," not having been shifted and sorted by running water. Definite "gutters," however, were found on the bed-rock at Lake-Austin Island and at Quin's.

The "reefs" have a high dip; and, where opened down to the water-level, often contain galena as well as iron-pyrites; in some cases copper-pyrites and antimony. For the most part they seem to be "fissure-veins," of variable size and extent. They have "shoots," or small parallel fissure-veins; and there are also "cross-courses," rich at their intersection of main north-and-south reefs, such as the "Star of the East," a true lode, but much broken.

The water-supply is good for the most part; excepting at the

Salt Lakes, Lake Austin, and elsewhere. The water-level in the mines is usually within 100 feet depth. Timber, however, is relatively scarce. The roads are bad at present.

Some large auriferous ironstone lodes are also met with, hematitic at top and pyritous below. In the Weld Range the exposed hematite is botryoidal, giving rise to the local opinion that it was a lava-flood. In some of the soft clayey bands of these lodes the Kangaroos scratch out caves; and the natives probably followed this plan in getting at the lode itself centuries ago, and here they still work (for the whites) with primitive wooden tools, cutting round a mass of the ore and then wedging it off. This ironstone was worked on a larger scale, and probably traded to great distances, before the white invasion of Western Australia. The red ochre of the lode has been mistaken for cinnabar.

The several mines and diggings are described in detail (pages 12–21); and, in conclusion, this Goldfield is regarded as exceedingly rich, and to have a brighter out-look than any other in the Colony; the distance to be traversed in getting to Kimberley, and the salt water of Yilgarn, being disadvantageous to them. Pilbarra and the Ashburton have not been proved to be large reefing districts.

T. R. J.

II.—On the Cranial Osteology of the Mesozoic Ganoid Fishes, *Lepidotus* and *Dapedius*. By A. Smith Woodward, F.G.S., F.Z.S.[1]

IN this paper the author describes the cranial osteology of *Lepidotus*, so far as decipherable from specimens discovered by Mr. Alfred N. Leeds in the Oxford Clay of Peterborough, and from Wealden specimens in the collection of the late Mr. S. H. Beckles. He then compares the skull with that of *Dapedius*, as shown by a fine specimen from the Lower Lias of Lyme Regis in the British Museum.

From the observations recorded it would be premature to make any very general deductions, the characters of the skull having yet to be discovered in the majority of the Mesozoic fishes. The new facts, however, are interesting as tending to confirm a conclusion that must have impressed everyone who has deeply studied these extinct fishes, namely, that it is impossible in Jurassic and Cretaceous formations to recognise any absolute sub division of the so-called ganoids into "Lepidosteoidei" and "Amioidei." The skulls of *Lepidosteus* and *Dapedius* differ from those of existing "ganoids" in exhibiting the backward extension of the basicranial canal; and the cartilaginous cranium of *Dapedius* is remarkably similar in every respect to that of the modern salmon (*Salmo*), except somewhat more ossified. Both *Lepidotus* and *Dapedius* agree with *Lepidosteus* and *Amia* in the fact that the membrane bones of the roof do not extend quite to the occipital border of the cranium; but *Dapedius* at least is distinguished from *Amia* and approximated to *Lepidosteus* by the course of the olfactory nerves across the orbital cavity, while *Lepidotus* is paralleled only by the last-named genus

[1] Abstract of paper read before the Zoological Society, June 20th, 1893.

in the absence of a gular plate. On the other hand, the superficial bones of the two extinct genera differ greatly from those of *Lepidosteus* and closely resemble those of *Amia*; the peculiar attachment of the premaxillæ in *Lepidotus*, for example, being reproduced almost in every detail in the last-named genus.

III.—On the Dentition of a Gigantic Extinct Species of *Myliobatis* from the Lower Tertiary Formation of Egypt.

By A. Smith Woodward, F.G.S., F.Z.S.[1]

THE Skates of the family of Myliobatidæ are well known to attain a great size, but few examples even of the dentition of the largest specimens are preserved in museums. It is, therefore, of much interest to record that the British Museum has lately received from Surgeon-Captain R. H. Penton a good example of the jaws of one of the most gigantic extinct species of *Myliobatis*, discovered in the Lower Tertiary Limestone of the Mokattam Hills, near Cairo, Egypt. So far as the present writer is aware, this is the largest specimen of the dentition of *Myliobatis* that has hitherto reached any museum.

The jaws were found in natural association, and the size of the teeth is indicated by the following table of measurements in fractions of a metre:—

	Upper Dentition.	Lower Dentition.
Width of median dental plate... ...	0·13 to 0·135	0·12 to 0·13
Length ,, ,, ...	0·18	0·014 to 0·016
Maximum width of three lateral series of plates...	0·02	0·02

From these measurements it is evident that the principal teeth in the lower jaw are about eight times, those of the upper jaw about seven and a half times as broad as long; while the maximum thickness of the same teeth in both jaws equals nearly one-quarter of their breadth. These characters, taken in conjunction with the form and proportions of the lateral teeth, suffice to distinguish the Makattam specimen from the dentition of all known species of *Myliobatis*; and it may therefore be named *M. Pentoni* in honour of its discoverer. In determining such specimens it is, of course, necessary to take into account the mode of growth of the teeth and their change in proportion with age; but it does not appear possible, in accordance with the ordinary laws of growth, for any known type of dentition to develop by increase of size into the one now described. The form of the lateral teeth and the transverse section of the median teeth seem to be nearly constant at all stages of growth in any one species.

Materials for comparison are unfortunately insufficient to form any certain estimate of the size of *Myliobatis Pentoni*; but if the few small examples of the recent *Myliobatis aquila* in the British Museum are at all similar in proportions, the maximum width of the disc of the extinct species cannot have been much less than five metres.

[1] Abstract of paper read before the Zoological Society, June 20th, 1893.

REVIEWS.

I.—Memoirs of the Geological Survey of the United Kingdom. The Jurassic Rocks of Britain. By C. Fox-Strangways, F.G.S. Vol. I., Yorkshire, pp. 551, including Index, price 8*s.* 6*d.* Vol. II. (Yorkshire) Tables of Fossils, pp. 250, price 12*s.* 1892. London: Kegan Paul, Trench, Trübner and Co., Limited.

AFTER a brief outline of the physical features of the district and the system of classification adopted, Mr. Strangways draws attention to the progress of geological enquiry with reference to the Jurassic rocks of Yorkshire. This piece of historical geology is not without interest to the general reader, since there is a touch of quaintness in the attempts of the earlier observers to account for so many natural curiosities. East Yorkshire, moreover, even before the days of Phillips, had attracted the notice of William Smith, the father of stratigraphical palæontology, and the genuine Yorkshireman may comfort himself with the reflection that this line of observation, which is the very backbone of geological science, was as much impressed on Smith's mind by an inspection of the Hambletons and the Howardians as by that of the Cotteswolds themselves. These hills, then, may share with the Cotteswolds the honour of having cradled the infant science, which found its first expression in "Strata identified by organized fossils." The region was subsequently rendered classic ground through the publications of Phillips, who brought the geology of East Yorkshire well to the front some sixty-four years ago.

To survey such a district and to write the official memoir on its geology was no unpleasant, if no very easy task. There is much that is difficult in the stratigraphy of certain parts of East Yorkshire, yet nothing that can be called absolutely obscure. The beds, too, vary both within the district itself, and also as a whole by comparison with those of other parts of England, yet not to such an extent but what they may be correlated. Hence the difficulties are not insuperable, yet sufficient to give zest to the enquiry and to yield credit when they have been fairly surmounted. The author commenced operations about the time when a long lull in the geological investigation of East Yorkshire had been succeeded by a period of awakening interest. The classical volume of Phillips possessed all the charm which usually belongs to a pioneer's work; whilst to the average compiler it seemed to have told the tale so completely that there was nothing left for the next generation but to accept without question his reading of the rocks. Yet there had long been doubts in some quarters as to the precise value of certain of Phillips' conclusions, and these doubts had found a partial expression in the writings of Oppel and Wright. The publication of the Survey Memoir on the Jurassic Rocks of the Midlands by Prof. Judd, the series of papers by Mr. Hudleston in the Proceedings of the Geologists' Association and the important work on the Yorkshire Lias by Messrs. Tate and Blake, all proceeded on the basis of original and independent investigation, free from too close an

imitation of antecedent opinion. Thus Mr. Strangways appeared on the scene at a very opportune moment, when the ground had to a certain extent been cleared, in anticipation, as it were, of his more complete and systematic survey.

His maps, which have appeared at intervals for several years past, must be regarded as a summary of the stratigraphy of the district and speak for themselves. It only remains for us to briefly notice his method of dealing with the Jurassic rocks of Yorkshire in the volumes now before us. The Introduction contains tables showing—(1) the various divisions of these rocks adopted at different periods, and (2) a comparative table of foreign equivalent formations. As regards the Palæontological equivalents here adopted we may remark that there appears a complete blank between the zone of *Am. plicatilis* (Corallian) and the zone of *Bel. lateralis*, which latter is almost post-Jurassic; nor is the division between Upper and Lower Kimeridge recognized in the Table, perhaps from the difficulty of drawing a line. Whilst on this subject we may add that the numerous Tables of Sections, etc., throughout vol. i. add greatly to the interest and value of the work.

The Lias occupies three chapters (119 pages), preceded by a table showing the zones into which the Lias of Yorkshire has been divided, its chief lithological divisions, etc. Each zone is then dealt with in detail, and a few of the characteristic fossils figured—and perhaps the figures might have been rather better. The present classification is somewhat changed from that adopted by the Survey in 1880; the Lower Lias is held to range from the *planorbis*-zone to the *capricornus*-zone; the Middle Lias comprises the *margaritatus*-zone (Sandy Series) and *spinatus*-zone (Ironstone Series); the Upper Lias is in four zones, from the *annulatus*-zone to the *jurensis*-zone inclusive. One of the most interesting and important features in connection with the Yorkshire Lias is the development of the Ironstone Series, of which full details are supplied. Taking Eston as the point of departure, sections are given showing the thickness and range of the seams of ironstone in three directions, viz. (1) Eastwards, along the northern escarpment, and thence by the coast to near Robin Hood's Bay; (2) South-eastwards, across the interior dales; and (3) Southwards, along the western escarpment to the neighbourhood of Thirsk. It is interesting to geologists, though less so perhaps to iron-miners, to note how the main Cleveland seam appears to diminish in economic value in all directions from its bold northern outcrop at Eston.

The extraordinary character of the Lower Oolites in Yorkshire necessitates a considerable amount of division. Hence we find that this portion of the Memoir occupies no less than seven chapters (126 pages). The peculiarity of an Estuarine series which is repeatedly split up by marine bands, themselves often richly fossiliferous, requires special treatment, and the more so since these marine bands present much difference of development within the area under consideration. Thus the Millepore Bed increases in importance towards the south and dies out entirely towards the

north, whilst that other great divider of the Estuarine series, the Gray or Scarborough Limestone, behaves in a manner the reverse of this. In the Howardians the equivalents of most of the marine beds, except the Cornbrash, may be recognized, but under different conditions of development.

A glance at plate iv. which illustrates the variations in thickness and mineral character of the Lower Oolites in Yorkshire, is very instructive in this connection. One cannot help noting that the 30 or 40 feet of "Estuarines" and Oolite at Kirkby Underdale, where deposit is at a minimum, practically mark the southern margin of what we may regard as the Yorkshire basin of deposition. From this point we perceive a somewhat irregular increase in a northerly direction until at least 700 feet of beds are recorded, exclusive of the Blea Wyke Beds, which would add some 70 feet more to the score of the Lower Oolites. It is almost needless to add that the details are well worked out in the text, and present many features of great interest alike to those who are acquainted with the district and to those desirous of becoming so.

The Middle Oolites, from the Kellaways Rock to the uppermost Corallian inclusive, are disposed of in three chapters (98 pages). Of course it is well known to students of Jurassic geology that "Kellaways Rock" and "Oxford Clay" in Yorkshire mean something very different from what these names imply in the south of England. This discrepancy arises from the necessity of adopting a lithological rather than a palæontological basis of subdivision in mapping the country. A glance at table v. of this memoir will show what a very subordinate part the "Oxford Clay" plays in many portions of the interior of the county. Throughout the Tabular range, in fact, until we approach the coast, it is nothing more than a few feet of sandy clay between two powerful arenaceous formations, the Kellaways Rock below, and the Lower Calcareous Grit above. Here also, as in the case of the Lower Oolites, we perceive a minimum of deposition as the southern margin of the Yorkshire Basin is approached at Acklam.

The Corallian Series, which constitutes the upper member of the Middle Oolites, is exceptionally well developed in Yorkshire. Mr. Strangways recognizes the two palæontological divisions of this series, which had been indicated by Messrs Blake and Hudleston, in their paper on the "Corallian Rocks of England" (Q.J.G.S. vol. xxxiii.). The lower division, which may be regarded as Upper Oxfordian, is the zone of *Am. Perarmatus* and includes the Lower Calcareous Grit. the Passage Beds, and the great series known as the Lower Limestone, although the top shell-bed of that formation gives indications of the change in the fauna which obtains in the higher beds. This may generally be distinguished from the Upper Limestone (Coralline Oolite and Coral Rag) by the prevalence of *Gervillia* instead of *Chemnitzia* (*Pseudomelania*). The two limestones are not easy to separate in the Howardian Hills, although at Appleton the fauna of the Passage Beds is clearly to be recognized. The solidarity of the two limestones in the Howardians is certainly in

favour of regarding all the beds above the Lower Calcareous Grit and below the Kimeridge Clay as parts of one system.

The zone of *Am. plicatilis* is held to include the Middle Calcareous Grit, where these beds are developed, as in the Hambleton and Tabular Hills, the Upper Limestone, and the Upper Calcareous Grit, together with its equivalent, the Cement-stone Beds of the eastern portion of the Howardians. As a matter of fact the Upper Calcareous Grit is non-existent in the Howardians, since the unexpected and exceptional development of Upper Calcareous Grit at Coxwold can scarcely be placed in this system of hills. The delimination of the Middle Calcareous Grit forms an important part of Mr. Strangways' work, the more so as the existence of this independent arenaceous series was never suspected by Phillips and the earlier geologists. He enumerates the fossils of the *Trigonia*-beds at Pickering along with those of the Middle Calcareous Grit, and notes the possibility of this horizon occurring at Middle Cave, near Malton, although it would, of course, be impossible to indicate on a map anything like Middle Calcareous Grit in the Howardians.

In dealing with the inner margin of calcareous rock which girdles the Vale of Pickering he indicates the possibility of a separate origin for the Coral Rag of the Ayton district from that of Pickering and the westward. The Coral Rag, in its typical form, rather fails about Pickering, being possibly represented by obscure calcareous beds, but as we go westwards towards Oswaldkirk a great variety of Coral-rock obtains and the sides of the quarries often present beautiful arabesques where the structure has been brought out by weathering. On the opposite side of the Vale, at North Grimston, the Coral Rag would seem to have attained its maximum development, but rapidly thins out southwards to complete extinction. The relations of this rock to the overlying cement-stone, chiefly formed from its denudation, and of both of them to the Kimeridge Clay above and the Lower Calcareous Grit below, constitute an episode in stratigraphy which renders the Birdsall district one peculiarly difficult of interpretation.

The Upper Oolites are dismissed somewhat briefly, one chapter of a dozen pages being all that is devoted to their consideration. Practically, the Upper Oolites in Yorkshire consist of the Kimeridge Clay, since the beds, recently distinguished as the zone of *Bel. lateralis*, have no title to be considered Portlandian, though they may possibly represent *in time* a portion of the Purbeck series.

It would seem that the mystery which has so long attached to the Kimeridge Clay of Yorkshire is still unsolved, and that no conclusive information is available as to what underlies those portions of the Vale of Pickering which lie between the great bounding faults. Mr. Strangways questions how far it is possible to trace the accepted divisions of the Kimeridge Clay in Yorkshire, the outcrop being usually covered by alluvium, "so that it is only in a few obscure sections in Filey Bay, at a few places towards the western end of the Vale of Pickering and along the western escarpment of the Wolds, which is much slipped and confused, that we get exposures of the beds."

The Upper Kimeridge consists of alternations of finely laminated, dark, bituminous and lighter shale, with hard brown bands, which have received special notice as forming the lower portion of the Speeton section. There is also a trace of the Upper Kimeridge at Settrington. All other exposures are in beds which must be referred to the Lower Kimeridge, which consists mainly of blue clays and shales with septaria. Some light has been thrown on the subject by boring at Irton: there are also feeble indications in the Vale of Pickering and the lowest slopes of the Tabular Hills. Undoubtedly the best section in the Lower Kimeridge was afforded by Sir C. Strickland's brickyard at Hildenley, three miles west of Malton, which yielded a most characteristic basal Kimeridge fauna, and there have also been a few fossils picked up on the Wold slopes, which clearly belong to the Lower Kimeridge. On the whole, however, the fauna of the Yorkshire Kimeridge seems somewhat meagre, and when we find (p. 381) *Rhynchonella inconstans* quoted as a "Portlandian" fossil, we can only express surprise that a form, which in the South of England is eminently characteristic of the very lowest Kimeridgian, should here be found on such a high horizon.

In chapters devoted to "Physical History" and "Scenery and Denudation" the author summarizes his experiences in accordance with his own views. Under the former heading he states his belief that the beds of the Yorkshire Lias were formed in a somewhat land-locked area, having its shore-line towards the north-west, whilst lying open towards the east. The South Yorkshire deposits were formed beyond this district, and constitute the northern limits of a more extended area. Towards the close of the Liassic period the bed of the sea was elevated, or the water became shallower from the gradual accumulation of material. In the west the upper part of the Lias has been subjected to considerable local denudation, whilst on the coast the Blea Wyke beds exhibit a considerable thickness of sandy shales with *Serpulæ*, *Trigoniæ*, etc., showing shallow-water conditions and forming a gradual passage from the Lias below. The exceptional preservation of these beds constitutes one of the most obscure problems in the physical history of the Yorkshire Jurassics, and Mr. Strangways, in this chapter, rather favours an explanation which he has elsewhere opposed.

The physical history of the Lower and Middle Oolites appears to afford evidence of a series of oscillations throughout the period, with sediment invading the area mainly from the west and north, in which direction the shore-line probably lay. The last discharge of mechanical sediment is recorded by the Middle Calcareous Grit, even after corals had begun to form in the area; but at last there came a cessation of mechanical impurities and a large extent of organic rock with corals concluded a phase in the history of the district. The peculiar marginal character of the Corallian limestones, forming an imperfect ring as they do round the clays of the Vale of Pickering, is attributed, and we think rightly, to the accidents of stratigraphy rather than to original deposition in that form. But

until the boring-rod has perforated the central mass of Kimeridge Clay in the Vale, the problem cannot be regarded as completely solved.

The general connection which exists between "Scenery and Denudation" has exercised the mind of many a field geologist; yet, as Mr. Strangways truly observes, there are few districts in England where the simplest forms of denudation are more clearly exposed than in the Tabular Hills and along the sea-coast; and he takes care to point out that the inequalities of the surface are mainly due to erosion, or to what some of the provincials would term "a wash out." He lays much stress upon initial direction in the formation of valleys and gorges, as being due to the original slope resulting from stratigraphical conditions. Since a large portion of the Jurassic rocks slope inwards towards the Vale of Pickering, a sort of horse-shoe arrangement is the result, and many interesting cases are cited.

No one at this time of day is likely to call in question the general proposition that the valleys and gorges which are found in this district result mainly from meteoric denudation; but the period during which such sculpturing has been effected is not always equally clear, and there are two well-known and extremely interesting cases, where the conclusions of Mr. Strangways appear not a little startling. One of these cases relates to the Derwent as it enters the Vale of Pickering, the other to the Derwent as it leaves the Vale, where it becomes the sole conduit of the accumulated waters of so many springs and brooks.

To appreciate these points fully one ought to know the district. But it may suffice to say that the Upper Derwent, in its course from the higher moorlands, after flowing past Hackness, enters a tolerably wide valley, which has a general easterly direction and leads to the sea-coast in about five miles. This Scalby valley has all the appearance of being the true continuation of the Valley of the Derwent, and Mr. Strangways points out that the natural tendency of the original stream would be towards the east at this spot, owing to a local anticlinal axis. In fact he has no doubt that this was the old course of the Upper Derwent. Yet to the surprise of everybody who has visited the spot, the Derwent, instead of following a good wide valley almost straight to the sea, has taken the trouble to cut a narrow gorge some 300 feet deep and one-and-a-half miles in length through the Middle Oolites, direct for the Vale of Pickering, and almost at right angles to what seems to have been its previous course. He considers that this result has been attained through the damming up of the lower end of the Scalby valley by glacial deposits, or possibly by the North Sea ice itself. If the whole of this amount of work was done since the commencement of the principal glaciation, we are fain to suppose that no inconsiderable portion of the sculpture of the country has been effected in Pleistocene times.

The case of the long and sinuous breach in the Howardians by which the Lower Derwent escapes into the Vale of York is somewhat analogous, as he considers that this has been effected by the

waters of the Pleistocene lake, caused by the damming up of the eastern end of the Vale of Pickering at Filey, which is still blocked by glacial deposits. Undoubtedly the Vale of Pickering held a lake, but if a 200 feet gorge has been cut through the entire breadth of the Howardians within the period claimed, even allowing for a pre-existing stream flowing towards the Vale, we must again acknowledge the immense amount of erosion which has been effected in Pleistocene times.

Attention is also drawn to this subject in reference to Cleveland, where the Jurassic rocks are encumbered by glacial deposits to a greater extent than elsewhere in East Yorkshire. One of the most characteristic features of this district is the number of rock gorges through which the existing streams flow, and which are due to the blocking of pre-glacial valleys by drift. Important inferences are drawn from the distribution of this drift throughout the Jurassic area. It is seen to cover a great part of the country north of the Esk, and in this region attains to considerable elevations. But neither over the high Moorlands south of that valley, nor throughout the Tabular Hills, has any been found, until we come to the local Drift of the lower slopes, which border the Vale of Pickering. From these facts he infers that the ice of the North Sea, impinging upon the coast of Cleveland, pushed its way nearly to the axis of the Jurassic highlands, and then divided into two streams, the westerly one moving down the Vale of York, whilst that to the east inclined to follow the coast-line. Clearly Mr. Strangways is not afraid of the "Glacial Nightmare."

Two chapters on Economic Geology conclude the first volume. The second volume is devoted to a most elaborate series of tables of fossils, prefaced by a very complete bibliography. The author observes that this catalogue was originally compiled, on a smaller scale, to facilitate the work of the Geological Survey, but that, having been found very useful in that connection, he considered its publication might be of some utility to students of this district. In this view we cordially agree, and we heartily congratulate Mr. Strangways on the completion of the entire Monograph.

II.—The Lower Silurian Brachiopoda of Minnesota. By N. H. Winchell and Charles Schuchert. Extracted from Vol. III. of the Final Report of the Minnesota Geological Survey. Chapter V., Plates XXIX. to XXXIV., June 6th, 1893.

THE authors of this Monograph, expert, industrious brachiopodists, collected the materials for their researches on the Lower Silurian Brachiopoda of Minnesota from the Upper third of the Trenton Limestone in the vicinity of Minneapolis and the Trenton shales near St. Paul's and Minneapolis. They adopt the names brachial=ventral, and pedicle=dorsal valves, and give clear and useful definitions of other terms employed. Hyatt's nomenclature is used for ontogenetical inquiries, for which, in some instances, abundant material was forthcoming. The classification agrees with that recently proposed by Schuchert, embodying Beecher's orders.

Waagen's sub-orders in part and generic emendations of Hall and Clarke.

Various species of *Lingula* are described, and it is held that the stages of growth indicate that the course of development of that genus was from *Paterina-Obolella-Lingula*. The allied sub-genus *Glossina*, Phillips, is restricted to the Palæozoic rocks. The author's new family, *Lingulasmatidæ*, is again defined. It comprises, at present, only two genera; one, *Lingulasma*, removed from the *Lingulidæ*, and the other, *Lingulops*, taken from the *Trimerellidæ*. They are the only Linguloids in which interior platforms are developed recalling the same structures in the *Trimerellidæ* which, however, Winchell and Schuchert do not regard as their direct descendants. They hold the *Lingulasmatidæ* to be a branch of *Lingula*, which originated in the Trenton times and terminated in the Niagara period. They were derived from *Obolella*, while *Monomorella* and *Trimerella* had *their* origin in *Dinobolus*. A small species of this genus (*Dinobolus? parvus*, Whitfield) occurs in the Galena formation of Wisconsin and Minnesota. It is allied to *D. Schmidti*, King and Davidson, from an Esthonian stratum almost equivalent in age with the Trenton Limestone of New York.

Several neotrematous and protrematous genera are discussed and new species and varieties proposed, among them a species of *Hallina* named *H. Nicolleti*, W. and S., after "Jean Nicollet, Geographer and Geologist of the North-West." It appears, however, that this supposed new species is considered by Hall and Clarke to be nothing more than *Atrypa exigua*, of which *Zygospira? aquila*, Sardeson, is also a synonym. All the species of the genus *Hallina*, W. and S., have been subjected to critical analysis on p. 151 of the first fascicle of part ii., volume viii., of the Palæontology of New York, issued July, 1893.[1] In this instalment of the second volume of their great work on Palæozoic Brachiopoda, Hall and Clarke announced the genus *Hallina* (type H. Saffordi, W. and S.) to be founded on incomplete preparations of a well-known shell. Hence these authorities are unable to recognise its terebratuloid characters, as it presents the main features of a Zygospiroid. For the smooth *Atrypa exigua=Hallina Nicolleti* the term Protozyga is proposed and its cyclospiroid affinities are recognised.

Mr. C. Schuchert has since abandoned the genus *Hallina*, in a communication published in the "Proceedings of the Biological Society of Washington," dated July 13th, 1893.[2] In conjunction with Dr. Beecher he announces his conviction that species of supposed Silurian primitive impunctate terebratuloids referred to *Hallina* and *Macandrevia* are spire-bearing forms, of which the earliest known genus is *Zygospira* occuring in the Bird's Eye limestone of the Trenton period. The details of the development of its

[1] An introduction to the study of the genera of Palæozoic Brachiopoda. By James Hall and John M. Clarke, fascicle i., part ii., vol. viii., text and woodcuts, Albany, July, 1893.

[2] Development of the Brachial supports in *Dielasma* and *Zygospira*. By Charles E. Beecher and Charles Schuchert.

spiral loop are discussed. It begins life as a simple centronelloid and is characterized by subsequent progression from one to six whorls in each spiral. Beecher and Schuchert express the opinion that the ontogeny and phylogeny of *Zygospira* indicate the derivation of the *Atrypidae* from forms with a centronelloid loop, consequently "the Ancylobrachia are older and more primitive than the Helicopegmata." In a secondary communication published the same date [1] Mr. Charles Schuchert discusses the development of the shell in *Zygospira recuvirostra*, for which species Davidson proposed the genus *Anazyga*. The genus *Zygospira* was founded by Hall in 1860, with *Producta modesta*, Say, as type from the Hudson River group. The genus is remarkable for the extreme variability in the position of the loop in different individuals. This variation is individual, not specific, and therefore Hall and Clarke reject Davidson's name *Anazyga* for the species *recurvirostra* of the genus *Zygospira*. According to Schuchert, the fourth stage of shell development is reached before the species "is recognizable as belonging to the suborder Rostracea, and apparently most closely related to the Rhynchonellidæ. The calcareous brachial supports make their appearance in a specimen about 1·33 mm. in length. This species is then referable to the Ancylobrachia, having a loop much like that of *Centronella*. This loop then passes through a series of metamorphoses, acquiring spirals when the shell is about 3 mm. in length."

It would seem from a cursory glance through Hall and Clarke's fascicle 1. part ii. vol. viii., Palæozoic Brachiopoda, which has just reached us, that about ten new genera and sub-genera are proposed for the spire-bearing genera of Brachiopoda. 1. Many of them seem to be interesting passage forms of an inter-generic character.

Messrs. N. H. Winchell and C. Schuchert have also described and figured "Sponges, Graptolites and Corals" from the Lower Silurian of Minnesota, in chapter iii. with two plates, an excerpt from the same Report.[2] Herein the authors discuss the curious fossil sponges *Receptaculitidæ*, a family referred by that excellent authority, Dr. G. J. Hinde, to the siliceous Hexactinellid order. Their systematic position, however, has been regarded as doubtful by Nicholson, on the grounds of Rauff's discovery that the original structure of the organism was calcareous, and it became silicified subsequently. Specimens of the genus *Receptaculites* occur from four to twelve inches in diameter in the Lower Silurian of Minnesota, where they are popularly known as the "sun-flower coral of the North-West." The authors give a useful synopsis of the American species of the genera *Receptaculites* and *Ischadites*, followed by an essay on the structure of the anomalous organisms they formerly named *anomaloides*, for which they now propose the correct and more suggestive name of *Anomalospongia*. They also give figures and descriptions of a species of hydroid *Solenopora* (*S. compacta Billings*), of species

[1] Development of the shell in *Zygospira recurvirostra*. By Charles Schuchert, Proc. Biol. Soc. Washington, vol. viii., pp. 71–82, pls. x., xi., July 13th, 1893.

[2] Final Report of the Minnesota Geological Survey, pp. 55–95, pls. F, G, June, 1893.

of *Diplograptus* and *Climacograptus*, and proceed to discuss the madreporoid corals *Lichenaria Streptelasmidæ*, *Poritidæ*, etc., and figure and describe *Aulopora trentonensis*, W. and S., the only Lower Silurian auloporoid known. AGNES CRANE.

III.—REVISION OF THE FAUNA OF THE MARINE OLIGOCENE OF THE ENVIRONS OF ÉTAMPES. By M. COSSMANN.

RÉVISION SOMMAIRE DE LA FAUNE DU TERRAIN OLIGOCÈNE MARIN AUX ENVIRONS D'ÉTAMPES. Par M. COSSMANN (Journ. de Conch. tome xxxii. pp. 330, *et sqq.*).

THIS descriptive Catalogue of the marine mollusca of the Oligocene beds to the south of Paris is a continuation of the author's work published in 1891. The whole is practically a revision of MM. Cossmann and Lambert's larger work[1] relating to the fossils of the same area; and had become necessary in view of the light thrown on the classification and nomenclature of Lower Tertiary fossils during the progress of M. Cossmann's Catalogue of the Eocene fossils of the Paris basin.

The bivalves having been disposed of in the first part, published in 1891, the section under review comprises only the Scaphopoda and Gasteropoda. Commencing with *Dentalium*, the author accepts the view of Prof. von Kœnen, that the forms hitherto referred to Hébert's *D. acutum* differ from that species, and *D. Novaki*, von Kœn., is substituted therefor.

Chiton Terquemi, Desh., is replaced by *C. Etrechyensis*, de Rocheb., the former name having been pre-occupied. M. de Rochebrune placed this species in the genus *Tonicia*, but, as M. Cossmann truly remarks, it is impossible to classify these fossils—which occur, as a rule, in single valves only, and deprived of many characteristic parts—in the same manner as their living representatives. Figures are given of *C. Poirieri*, de Rocheb., of which the anterior valve is unknown.

In his catalogue of the Eocene mollusca the author referred to the genus *Basilissa*, Watson, a certain number of shells possessing conical striæ, slightly perforated, thick peristome, with columella inflated and abruptly terminated anteriorly. On second consideration he is now disposed to include them in *Thalotia*, a subgenus of *Elenchus*. The *Trochus subcarinatus*, Lamk., of the Paris basin Oligocene possesses a columella in every way comparable with that of *Elenchus Lehmanni*, Menke, of the Australian seas, and differs only from that species in not having the lip guttered interiorly, which the author regards as an unimportant character. The embryo in both species is of the same dimensions, whilst the ornamentation of the spire is very similar, and the lip presents the same obliquity. We entirely agree with the author that the Oligocene shells under discussion are not *Basilissa*, and that they may properly be referred to *Thalotia*, but some of the thin, fragile Eocene forms appear to be identical with Watson's genus. Five

[1] Mém. Soc. Géol. France, 3e ser. iii. (1884).

species from Étampes, hitherto classed with *Trochus*, are now to be called *Elenchus*. *Trochus bicarinatus*, Lamk., has been expunged from the catalogue on the ground that only one example of the species is known, and that is probably a deformation of *Elenchus subincrassatus*. The genera *Gibbula* and *Turbo* are represented by one species each, and *Collonia* by two.

Neritopsis Lorioli, Cossm. and Lamb. is very properly transferred to *Nerita*; and *Neritina propinqua*, Cossm. and Lamb. is merged into *N. Duchasteli*, Desh., of which it is only the adult form. There are five species of *Odontostomia*; one, *O. Lamberti*, being new. Passing to the genus *Raulinia*, which both Fischer and Tryon have classed with the Littorinidæ, the author shows that it more properly finds a place in the Pyramidellidæ, close to *Odontostomia*, a conclusion arrived at from the study of the embryo. Two species of *Raulinia* are found near Étampes. Amongst the Pyramidellidæ, also, a new genus *Belonidium*, is proposed, of which the type is *Aciculina gracilis*, Desh.

The well known *Ampullina crassatina*, Lamk., is correctly referred to the genus *Megatylotus*, characterized, amongst other things, by an immense, broad, columellar callosity, sharply defined. The author seizes the opportunity to give the geographical distribution of this species. *Truncatella Bezanconi* is the name given to a new species discovered at Jeurre; we believe it is the sole representative of the genus in the Oligocene beds, although two species have been described from the Parisian Eocene.

Dealing next with *Hydrobia* we take objection to the figure and description, in a work devoted to Paris basin fossils, of a new Spanish species, *H. Rodillensis*, which is entirely out of place, even though it is incidentally alluded to in connection with *H. Dubuissoni*, Bouillet, a common form at Étampes. *Littorina obtusangula*, Sandb., a species occurring in the Mayence basin, has been added to the fauna under notice by the discovery of an unique specimen. Four species of *Lacuna* are found; one of them, *L. stilpna*, which is figured, was formerly referred in part to *L. striatula*, von Kœn., now said not to occur in the Étampes area.

The fact that Mr. R. B. Newton has shown that *Bayania semidecussata*, Lamk., is synonymous with the earlier *B. corrugata*, Lamk., seems to have escaped M. Cossmann's attention.

We cannot conclude our observations on this very valuable contribution to our knowledge of the Paris basin Oligocene mollusca, without expressing a regret that its learned author did not include in his revision the mollusca from the same horizon of other parts of the basin; they are not numerous and would have entailed but very little additional labour. The catalogue would then have been more comparable with his Eocene work. We may point out also that the title "marine" is not strictly correct as applied to the paper under review, seeing that several extra marine forms are described in it. It is a pity they were not all included, and the title suitably altered; but we are, perhaps, expecting too much. The work, so far as it goes, is most excellent. G. F. H.

CORRESPONDENCE.

Sir,—I have read with much interest the references made by Sir Henry H. Howorth to Glacial action in Iceland, in the course of his article in your July Number, pp. 302–309.

Having travelled through the country twice (1890 and 1891), mainly in quest of the summit of its highest peak, which was reached during the latter journey, I have had good and numerous opportunities of observing the peculiarities of its mountain structure.

On the whole, there can be no doubt as to the general result being decidedly in favour of Sir Henry's view. The instances he refers to are, however, of varying value. The gnarled points of such ridges as those of Almannagja can hardly be regarded as offering conclusive proof, since these are lava splits, and of too recent (geological) date to found an extensive inference upon; nor will Mr. Baring Gould's remarks as to the aqueous origin of apparently glacial striations apply to the marks which are plentiful at certain intermediate levels upon the mountains. These may be found, especially among the valleys leading to the Eastern fjörds, in positions too high above flood courses to permit of such an explanation. Nor will Mr. Watts' remarks as to the extension of the southern glaciers command universal acceptance now. On the other hand, however, it is of the utmost importance to notice that among the hard basalt masses of the east and south-east, the lower ridges up to the height of about 1000 to 1500 feet are often rounded, and striations are not uncommon; but above that height, at elevations which increase as one travels inland, these rounded hill-tops disappear, and sharp pinnacles form the rule. So sharp are these pinnacles that it takes a stranger some time to realize that they are not columns built upon the mountain summits. In point of fact each is the nucleus of the uppermost layer of the Trap beds, from which the rest of that bed has split away. Here is a far older and safer guide, telling of a time when many of these valleys, up to a certain level, had their glaciers; which, however, never formed part of an ice-cap to the island. So marked is the distinction between these peaks, rounded and pinnacled, that the conviction I have stated fairly forces itself upon one.

Further west along the south coast evidence of another kind is forthcoming from the volcanic masses which there replace the basalt of the south-east and north-west. So soft are many of the ridges that, on the hypothesis of a huge grinding ice-cap, they ought to have disappeared altogether. Yet there they remain, loose, shaly-laminated ridges, between which, in the valleys, lie enormous snow-fields with drainage glaciers coming down to sea-level now and overtopping lower hills, just as the most easterly ones used to do. On every hand signs abound, both of advance and of retreat, on the part of glaciers accommodating themselves to the inequalities of their beds, but none whatever of ice above a definite ascending level, nor of excavations beneath that level.

It is true large quantities of mud are brought down by such

rivers as the Jökulsá, but it would be strange if glaciers, twelve miles *wide*, did not produce such results by mere surface erosion. The wonder is they bring so little. But of this the probable explanation is the gentle fall—which I have ascertained to be about 100 feet per mile of progress in the case of the Breithamerkr—and the few uncovered ridges or peaks from which material may fall upon the ice.

FREDK. W. W. HOWELL.

10, HANDSWORTH WOOD ROAD, BIRMINGHAM,
July 14*th*, 1893.

OBITUARY.

JAMES WILLIAM DAVIS, F.L.S., F.G.S., F.S.A.

BORN APRIL 15, 1846. DIED JULY 21, 1893.

IT is with deep regret that we announce the death of Mr. James Wm. Davis, of Chevinedge, Halifax, at the comparatively early age of 47. A Yorkshireman of fine physique and robust constitution, endowed with apparently unlimited energy, the sad news of his loss has come as an unexpected shock to his large circle of friends both at home and abroad. His more intimate acquaintances were aware that a slight injury to a blood-vessel in the brain caused his retirement from active life for a few weeks last autumn; and they further learned with sorrow that a recurrence of the same malady last March necessitated a still longer period of rest at the little village of Grassington, in North Yorkshire. His letters, however, were cheerful, only marred by some feebleness in the handwriting, and when he returned to his seaside residence at Bridlington about the end of June, there were hopeful signs of speedy recovery. Mr. Davis' eagerness to fulfil his municipal duties at Halifax, however, led to an unwise visit to the town of which he was for the third time Mayor. The fatigue and unwonted excitement produced almost complete paralysis, and his wife, family, and friends had soon to mourn over his decease, which took place early in the morning of July 21st.

Descended from a Gloucestershire family, Mr. Davis was born at Leeds on April 15th, 1846. He was educated at the local Grammar School, and at an early age entered the cloth-dyeing business of his father. He and a brother soon became partners in the firm, which transferred its business to Greetland, near Halifax, and for the remainder of his life Mr. Davis took the leading share of its management. In 1876 he built his fine residence, Chevinedge, on a wooded ridge of Carboniferous Sandstone overlooking Greetland, and there are few geologists of note in Britain who have not enjoyed the hospitality of that modern English home.

Though deeply absorbed in his own business and in certain collateral undertakings—though taking a prominent position in every educational, municipal, and political movement in his own town and district, and elected Mayor of Halifax no less than three years in succession—Mr. Davis found time not only to become a well-known and valued patron of Art and Science, but also to rise

to a high position as an investigator in Geology, Palæontology, and Archæology. Scientific work was, indeed, his solace and recreation. From his earliest boyhood, he was imbued with an ardent liking for the pursuit of Natural History; and in company with his friend and former neighbour, Mr. Percy Sladen, he was long occupied with practical work in Comparative Anatomy to enable him to carry on his future researches in interpreting fossil vertebrata. Only last winter, when Mr. Davis penned a long letter of woes to the writer of this notice, detailing how the whole of a new extension of his business premises had been burned down in one night, he concluded with the remark that all worries were just to be buried for two hours by the peaceful contemplation of *Acanthodes*—a Carboniferous fish on which he was writing a memoir for the Royal Dublin Society. Provided with what he termed a "prime Havana" and surrounded by piles of books and fossil fishes, Mr. Davis always found himself indeed in perfect peace and enjoyment.

From his earliest youth Mr. Davis had been connected with the Yorkshire Scientific Societies, and he first entered a wider sphere in 1873 by becoming a Fellow of the Geological Society of London and a member of the British Association. In 1875 he received the Fellowship of the Linnean Society, and also later that of the Society of Antiquaries. In 1891 he became a member of the Council of the Geological Society. Since 1876 he had been Honorary Secretary of the Geological and Polytechnic Society of the West Riding of Yorkshire, and brought the Proceedings, which he edited, to a high standard of value. In 1888 he organized the jubilee meeting of that Society, and subsequently wrote a volume detailing the history of its fifty years' work. He had occupied the Presidential chair of many local societies, was an active member of the Yorkshire Naturalists' Union, and an elected Governor of the Yorkshire College. He rarely missed the meetings of the British Association, where his keen business capacity was highly valued in the committees; and the circle of friends who had the privilege of being his guests at Chevinedge during the Leeds meeting in 1890, will never forget his qualities as a host on that occasion. In scientific journalism, too, Mr. Davis undertook no inconsiderable share of work. He was one of the directors of the "Westminster Review," and, if the London "Sun" can be trusted on a subject that has hitherto remained obscure, he was one of the promoters and chief supporters of Messrs. Macmillan's monthly, "Natural Science," a journal that has already attained a prominent position as a critical review of current matters in Geology and Biology.

In original research, as shown by the list of papers appended, Mr. Davis made many important contributions to knowledge of the Geology of Yorkshire; and in 1878, he co-operated with Mr. F. A. Lees, the Botanist, in a volume on "West Yorkshire: its Geology and Botany." He was also Secretary of the British Association Committee for the exploration of the Raygill Fissure, and took considerable part in many archæological investigations in the county, In Geology and Palæontology, however, Mr. Davis will longest be

remembered by his numerous contributions to Fossil Ichthyology. The fish-remains discovered in the Yorkshire coal-field early attracted his attention and excited his interest; and after making the acquaintance of the late Earl of Enniskillen and Sir Philip Egerton at the Belfast Meeting of the British Association in 1874, he began the study of extinct fishes in earnest. He visited Florence Court and Oulton Park, where he was always a welcome guest, to study the great Enniskillen and Egerton Collections, subsequently acquired by the British Museum. He also travelled extensively abroad, and the present writer will always treasure the most pleasant recollections of several journeys in the company of Mr. Davis to the museums of Holland, Belgium, France, Germany, Austria, Hungary, Italy, Denmark, Sweden, and Russia. He made copious notes and drawings of fossil fishes in all these museums, and many of them were afterwards utilized in his publications. His first researches on the Carboniferous fish-remains soon extended to the fossils of later formations, notably those of the Lias and the Chalk; and since 1883 he had published a series of large memoirs in the Transactions of the Royal Dublin Society.

Mr. Davis' work in Fossil Ichthyology bears many indications of the difficulties under which it was produced. The investigations, it must be admitted, were not always thorough; and the results are not always so concisely and accurately expressed, with such evidence of a fulness of knowledge of the subject as a trained professional specialist would desire. We are happy to say, however, British science is still far from being under the control of a narrow professional monopoly, and long may this freedom remain. Mr. Davis has, even under the most difficult circumstances, been one of the largest contributors to our knowledge of fossil fishes during the last 20 years. His larger memoirs are exquisitely illustrated, as are also several of the smaller ones; and where he has fallen into errors he has done much for progress by rousing up other workers to correct them.

While investigating the fishes of the Yorkshire Coal-field, he made a very large collection in a more systematic manner than had previously been attempted; and Mr. Davis' writings contain more information concerning the remains of the sharks of the Coal-measures than is to be found elsewhere. His memoir on "The Fossil Fishes of the Carboniferous Limestone Series of Great Britain" (1883) is the only extended, illustrated account of the Elasmobranch teeth and spines of the Lower Carboniferous Rocks, and is based chiefly on the Enniskillen Collection. His subsequent memoir on the Cretaceous Fishes of the Lebanon contains a wealth of new matter, and marks a very valuable advance, notwithstanding all unfavourable criticisms that have been passed upon it. His further writings on the Cretaceo-Tertiary fishes of New Zealand and on the Cretaceous fishes of Scandinavia are pioneer monographs, dealing almost exclusively with untouched materials. Finally, Mr. Davis' latest work on the fish-remains of the British Coal-Measures, of which only one part has been issued, promised to bring together

a great mass of material that had too long been neglected, and it is a distinct loss to Palæontology that the author's untimely end should have abruptly terminated the publication. We understand that the second part of this memoir, on the Acanthodians, is so near completion that it may be published posthumously.

A notice of the life and scientific work of Mr. Davis would, however, be very incomplete if we merely referred to his official responsibilities and his original researches. No one could come in contact with him for long without absorbing some slight proportion of his enthusiasm, his indomitable energy, and determination; and for at least 20 years he has probably had more influence than anyone else on the advance of scientific research in his native county. Many naturalists now occupying a conspicuous position in their respective lines of study owe their first kindly encouragement to him; many others have been incited to redoubled energy by personal intercourse with him. As the highly esteemed friend of most of the leading geologists both in Britain and on the adjoining Continent, and numbering in his large circle of acquaintances men distinguished in every sphere, Mr. Davis was a trusted adviser in many matters where only one with his great experience of the world could be of service. None, indeed, but those who have thus known him, can appreciate the loss which the scientific community has sustained by his decease.

Finally, we must add a word concerning Mr. Davis' liveliness of disposition, which kept him in the best of humour even in the midst of troubles and difficulties. Whether the worry were great or small, he could invariably lose all remembrance of it at will and apparently enjoy life as if nothing unfortunate had happened. The writer has a vivid recollection of being roused up in the middle of the night on one occasion at a remote railway station in Finland, when Mr. Davis was trying to explain to a clamorous crowd of officials that he had no ticket, but plenty of British paper money, which he would change at the end of the journey. After long discussion in a medley of languages, he induced the conductor to feel the weight of his "effects," which he suggested would be equal in value to the ticket, and the train was then allowed to proceed. Immediately afterwards, in the best of good humour, he pulled out from his portmanteau a small Swedish toy bought for one of his children, and playing with it, he remarked that it was well the inquisitive officer had not estimated the value by inspection. He resumed his slumbers, and as soon as an appropriate place was reached, borrowed from the same conductor enough Russian money to pay for breakfast. He never despaired, never regarded trouble too seriously—he was a friend whose companionship was truly cheering. A.S.W.

List of Memoirs and Papers by James William Davis, F.G.S.

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3. The physical forces which have caused the present configuration of the Valley of the Calder in Yorkshire. Geological Magazine Dec. II. Vol. V. (1878), pp. 500–508.
4. On the Occurrence of certain Fish-remains in the Coal-measures, and the evidence they afford of their fresh-water origin. Brit. Assoc. Rep. (1878), p. 539; Proc. Yorkshire Geol. Soc. vol. vi. (1879), pp. 40–52.
5. Erratic Boulders in the Valley of the Calder [1875]. *Ibid.* vol. vi. (1879), pp. 93–100.
6. The Stems and Roots of Fossil Trees in the Lower Coal-measures at Wadsley, near Sheffield [1876]. *Ibid.* vol. vi. (1879), p. 79.
7. Unconformability of the Permian Limestone to the Red Rocks west of its Escarpment in Central Yorkshire [1877]. *Ibid.* vol. vi. (1879), pp. 280–308.
8. Notes on *Pleurodus affinis*, sp. ined., Agassiz, and description of three spines of Cestracionts from the Lower Coal-measures [1878]. Quart. Journ. Geol. Soc. vol. xxxv. (1879), pp. 181–187.
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10. On the source of the Erratic Boulders in the Valley of the River Calder, Yorkshire. Geol. Mag. Dec. II. Vol. VI. (1879), pp. 313–321; Proc. Yorkshire Geol. Soc. vol. vii. (1881), pp. 141–154.
11. Description of a New Species of Fossil Fish-spine, *Ctenacanthus minor*, from the Lower Coal-measures of Yorkshire. Geol. Mag. Dec. II. Vol. VI. (1879), pp. 531, 532.
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13. On the Teleostean Affinities of the Genus *Pleuracanthus*. Ann. Mag. Nat. Hist. ser. 5, vol. v. (1880), pp. 349–357.
14. On a new species of *Gyracanthus*, a Fossil Fish from the Coal-measures (*Gyrac. denticulatus*). *Ibid.* ser. 5, vol. vi. (1880), pp. 372, 373.
15. On the genus *Pleuracanthus*, Agass., including the genera *Orthacanthus*, Agass. and Goldf., *Diplodus*, Agass., and *Xenacanthus*, Beyr. Quart. Journ. Geol. Soc. vol. xxxvi. (1880), pp. 321–336.
16. On a Group of Erratic Boulders at Norber, near Clapham, in Yorkshire [1880]. Proc. Yorkshire Geol. Soc. vol. vii. (1881), pp. 266–273.
17. On the Distribution of Fossil Fishes in the Yorkshire Coal-fields [1880]. *Ibid.* vol. vii. (1881), pp. 228–241; Proc. Geol. Assoc. vol. vi. (1881), pp. 359–370.
18. Report of the Raygill Fissure Exploration Committee [1880]. Proc. Yorkshire Geol Soc. vol. vii. (1881), pp. 300–305.
19. On the Exploration of a Fissure in the Mountain Limestone at Raygill. Brit. Assoc. Rep. (1881), pp. 645, 646.
20. On *Palæospinax priscus*, Egerton. Ann. Mag. Nat. Hist. vol. vii. ser. 5 (1881), pl. xx. pp. 429–432.
21. On the genera *Ctenoptychius*, Agassiz; *Ctenopetalus*, Agassiz; and *Harpacodus*, Agassiz. Ann. Mag. Nat. Hist. ser. 5, vol. viii. (1881), pp. 424–427.
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24. On the Fossil Fish-remains from the Armagh Limestone in the Collection of the Earl of Enniskillen. Proc. Geol. Soc. vol. xxxviii. (1882), pp. 12, 13.
25. On the Fossil Fishes of the Carboniferous Limestone Series of Great Britain [1882]. Trans. Roy. Dublin Soc. Sci. vol. i. (1883), pp. 327–600, plates xlii–lxv.
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27. Description of a new species of *Ptycholepis* from the Lias of Lyme Regis. Ann. Mag. Nat. Hist. series 5, vol. xiii. (1884), pp. 335–337, pl. x.

28. Description of a new Genus of Fossil Fishes from the Lias. *Ibid.* series 5, vol. xiii. (1884), pp. 448–453, pl. xvi.
29. On some remains of Fossil Fishes from the Yoredale Series at Leyburn in Wensleydale. Geol. Mag. Dec. III. Vol. I. (1884), pp. 91, 92.
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31. On a New Species of *Heterolepidotus* from the Lias. *Ibid.* vol. viii. (1884), pp. 403–407, pl. xxii.
32. On the contortions of the Chalk at Flamborough Head. *Ibid.* vol. ix. (1885), pp. 43–49.
33. Note on *Chlamydoselachus anguineus*, Garman. *Ibid.* vol. ix. (1885), pp. 98–113, pl. xi.
34. On the relative age of the remains of Man in Yorkshire. *Ibid.* vol. ix. (1886), pp. 201–214.
35. On some remains of Fossil Trees in the Lower Coal-measures at Clayton, near Halifax. *Ibid.* vol. ix. (1886), pp. 253–256.
36. On the Exploration of the Raygill Fissure in Lothersdale. *Ibid.* vol. ix. (1886), pp. 280, 281.
37. On some Fish-remains from the Tertiary Strata of New Zealand. Geol. Mag. Dec. III. Vol. III. (1886), pp. 93, 94.
38. Notes on a Collection of Fossil Fish-remains from the Mountain Limestone of Derbyshire. *Ibid.* Vol. III. (1886), pp. 149–157.
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40. On *Chondrosteus acipenseroides*, Ag. Quart. Journ. Geol. Soc. vol. xliii. (1887), pp. 605–616, pl. xxiii.
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51. On the Dentition of *Pleuroplax* (*Plewodus*) A. S. Woodw. Ann. Mag. Nat. Hist. ser. 6, vol. v. (1890), pp. 291–294, pl. xiii.
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